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BIOSTRATIGRAPHIC STUDY OF MIOCENE OSTRACODA OF NEW JERSEY, MARYLAND, AND VIRGINIA[1]

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ABSTRACT—Study of Ostracoda in middle and upper Miocene beds of New Jersey, Maryland, and Virginia indicates that the section can be divided into four substages and six faunizones. The Kirkwood formation of New Jersey is correlated with the upper part of the Calvertian substage, the *Trachyleberis exanthemata* zone. Paleoecological analysis suggests that the sediments were deposited on the continental shelf in shallow warm water.

A hinge classification for Ostracoda, including two new terms, crasidont (mixed dentition) and archidont (primitive dentition), is proposed. Summary of the order of development of significant characters in molt stages shows that the mature hinge is the last ontogenetic character to develop.

Limits of variation of several species are plotted graphically, showing continuities and discontinuities in fossil populations. Seven new species and one new subspecies of Ostracoda are described.

INTRODUCTION

ALTHOUGH the Miocene strata exposed on the Atlantic coastal plain in Virginia, Maryland, and New Jersey have been investigated for more than a century, the writer undertook a reexamination of their microfauna for the purposes of (1) making a systematic study of the Ostracoda; (2) establishing criteria for the subdivision of the Miocene section of that area, and (3) interpreting the stratigraphy by microfaunal analysis.

The Miocene sections in Maryland, exposed in the Calvert Cliffs, came to the attention of naturalists as early as 1669. Clark et al (1904) have given a comprehensive summary of investigations of the Miocene of the middle Atlantic slope prior to 1904. In this report Shattuck divided the Maryland Miocene into 24 "zones," numbered from 1 to 24 in ascending order, based on lithologic character and on occurrences and relative abundance of certain Mollusca or molluscan assemblages. The history of discoveries and of the unravelling of the Miocene stratigraphy in New Jersey is given by Richards and Harbison (1942). The 1912 work of Clark and Miller contains a summary of early studies in Virginia.

Types and figured specimens of the species described in this paper have been deposited at the United States National Museum; duplicate specimens have been sent to Columbia University and to the Henry V. Howe Collection at Louisiana State University.

The writer studied Edwards' (1944)

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types, Ulrich and Bassler's (1904) types, and F. M. Swain's (1948) types, at the United States National Museum; Coryell and Fields' (1937) types at Columbia University; and topotype material from the *Arca* zone of the Choctawhatchee formation (Howe, 1935).

Photographs were made by Neville M. Curtis, Jr. The writer was assisted in the field by her mother, Mary B. Malkin.

Distribution and character of the Miocene formations.—The Miocene formations lie in a broad southwest-trending belt extending along the coastal plain from eastern New Jersey to southern Virginia. Throughout much of its extent the Miocene is in unconformable contact with the eroded surface of the Eocene strata, resting on progressively older Eocene beds as it is traced inland. Near Washington, D. C., Miocene beds lie on Lower Cretaceous beds; in southeastern Virginia the inner edge of the upper Miocene outcrop lies on the crystalline basement. Outcrops of Miocene strata are relatively few because of the presence of mantling Quaternary terrace gravels and alluvium, and because of the absence of cuestas and lack of dissection in the coastal plain topography.

The Miocene formations under discussion include beds of middle and late Miocene age. No lower Miocene beds are exposed north of the outcrop of Trent marl in North Carolina although some may exist in the subsurface near the coast. The upper Miocene beds are called Yorktown formation in Virginia, where they are marine; Cohansey formation in New Jersey, where they are nonmarine. None is exposed in Maryland. The middle Miocene sediments are called Kirkwood formation in New Jersey, and are divided (youngest to oldest) into St. Marys formation, Choptank formation, and Calvert formation in Maryland and Virginia (Chesapeake group of Darton, 1891). The sequence and correlation of the several stratigraphic units is shown in figure 2. Distribution of Miocene formations and localities from which samples were collected for the present study are shown in figure 1.

SAMPLE LOCALITIES

Locality 7: Marl pits and spoil heaps on I. A. Sheppard farm, 3.6 miles northwest of Shiloh, Cumberland County, New Jersey, on farm road 0.3 mile south of Highway New Jersey 49 and 0.9 mile west of Shiloh-Roadstown road.

Sample NJ-9: Middle Miocene, Kirkwood formation. Bluish-gray, weathering to buff, silty to fine sandy marl (calcareous, arenaceous clay) and marly sand (or calcareous, argillaceous sand), with rare mica, calcareous fragments, and very rare black (phosphatic?) fragments; abundant Mollusca and molluscan fragments, rare to common Foraminifera and Ostracoda, echinoid spines; rare diatoms.

Locality 9: Cliff on west shore of Chesapeake Bay, 0.6 mile south of Plum Point Wharf, Calvert County, Maryland.

Sample MD-12-1: Middle Miocene, Calvert formation, Plum Point member, "Zone 10" of Shattuck (1904). Two feet of greenish-gray slightly argillaceous fine-grained subangular quartz sand with a few grains of glauconite and rare phosphatic (?) fragments; abundant shells and shell fragments, and common microfauna; exposed at base of cliff.

Locality 10: Randle's Cliffs Beach, on west shore of Chesapeake Bay, 1.6 miles south of Chesapeake Beach (Seaside Park on later maps). An almost vertical cliff is made accessible for sampling by a ladder and stairway leading to a private wharf.

Sample MD-13-5: Middle Miocene, Calvert formation, Plum Point member, "Zone 10." Brown to buff fine-grained phosphatic sandy marl with abundant Mollusca and shell fragments, echinoid spines, common Foraminifera and Ostracoda, very rare diatoms. 7 feet

Sample MD-13-6: "Zone 9." Dark buff to blue-gray fine-grained argillaceous, silty and marly sand with abundant molluscan fragments, echinoid spines, sponge spicules, common Foraminifera, rare Ostracoda. 5 feet

Sample MD-13-3: "Zone 6." Light bluish-gray silty clay with abundant shell fragments, sponge spicules, and echinoid spines, very abundant diatoms, fairly common Foraminifera and Ostracoda; 13 ft. below MD-13-6. 6 feet

Sample MD-13-4: "Zone 5." Light buff to gray silty to sandy porous clay with shell fragments, very abundant diatoms, rare Foraminifera and Ostracoda. 5 feet

Sample MD-13-8: "Zone 4." Gray highly fossiliferous sandy shell marl with common diatoms, abundant Foraminifera, common Ostracoda and echinoid spines; abundant dark phosphatic (?) fragments. 8 inches

Sample MD-13-7: Middle Miocene, Calvert formation, Fairhaven member, "Zone 3." Light gray porous, fairly well lithified fine-grained argillaceous angular quartz sand or

sandy clay, with shell fragments, echinoid spines, abundant diatoms, Radiolaria, Foraminifera, rare Ostracoda. Exposed to base. 3 feet

Locality 11: Cliff on west side of Chesapeake Bay, 0.4 mile south of Kenwood Beach (Governor Run), Calvert County, Maryland.

Sample MD-14-6: Middle Miocene, Choptank formation, "Zone 19." Yellow medium-grained sub-rounded quartz sand with some marly clay, phosphatic (?) fragments, very abundant shells and echinoid spines, fairly common Foraminifera and Ostracoda, very rare diatoms. 7 feet

Sample MD-14-5: "Zone 17." 12 feet below "Zone 19." Light bluish-gray marly clay with abundant shell fragments and echinoid spines, abundant Foraminifera and Ostracoda, very rare diatoms. 13 feet

Sample MD-14-1: "Zone 14." 13 feet below top of "Zone 17." Light gray sandy shell marl with abundant Mollusca and fragments, common Foraminifera and Ostracoda, rare diatoms. 3 feet

Sample MD-14-4: "Zone 14." Buff to gray sandy clay with black phosphatic (?) pellets, shell fragments and calcareous fragments, common diatoms, fairly common Foraminifera, rare Ostracoda. 4 feet

Locality 18: Cliff on west side of Chesapeake Bay, 2 miles south of Cove Point, Calvert County, Maryland.

Sample MD-18: Middle Miocene, St. Marys formation, "Zone 22." Gray medium-grained sub-rounded quartz sand with some calcareous clay, sparse glauconite; abundant Mollusca and fragments, and disarticulated plates of *Ophiura marylandica*, very rare Foraminifera and Ostracoda. Sample from inside *Fulgur* shells 20 feet above beach level.

Locality 17: Cliff on York River, 2 miles southeast of Yorktown, York County, Virginia.

Sample VA-17: Upper Miocene, Yorktown formation. Blue-gray very fine-grained argillaceous to marly glauconitic, micaceous quartz sand with common shell fragments, echinoid spines, abundant Foraminifera and common Ostracoda. Sample from inside *Venus* shell.

Locality 20: Cliff on York River, 1.2 miles southeast of Yorktown, York County, Virginia.

Sample VA-10: Upper Miocene, Yorktown formation, 14 feet below top of cliff. Yellow argillaceous, calcareous, limonitic, glauconitic sand, with abundant Mollusca, common Foraminifera and Ostracoda. 3 feet

Sample VA-2: Yellow sandy calcareous, limonitic, glauconitic clay with very abundant *Crepidula* and other Mollusca, common Foraminifera and Ostracoda. 5 feet

Sample VA-3; VA-12: Yellow limonitic, glauconitic sandy shell marl with abundant *Balanus*, *Pecten*, and *Venus*, water-worn shell fragments, common Foraminifera and Ostracoda. Exposed. 2 feet

Locality 21: Bluff at Carter's Grove on north shore of James River, 4 miles northwest of Ft. Eustis, approached through private estate of McRae (heirs of Archibald McRae) from Highway U. S. 60, 0.3 mile east of Grove, James City County, Virginia.

Sample VA-5: Upper Miocene, Yorktown formation, 19 feet below top of cliff. Gray sandy slightly glauconitic limestone with rare, poorly preserved microfauna and abundant shell fragments. 2 feet

Sample VA-7: Gray, sandy, somewhat indurated glauconitic coquina, with common Foraminifera and Ostracoda, many of which are coated with secondary crystalline calcite. 4 feet

Sample VA-4; VA-9: Gray, highly calcareous, glauconitic sandy shell marl with common Foraminifera and Ostracoda. 2 feet

Sample VA-8; VA-11: Gray, highly calcareous, glauconitic sandy marl or shell marl, some of which is well indurated; abundant Mollusca, common Foraminifera, rare Ostracoda; shells and microfossils with secondary coating or replacement of calcite. 3 feet

Sample VA-6: Gray medium-grained sparsely glauconitic quartz sand with small proportion of calcareous clay, abundant shells and fragments, rare to common Foraminifera and rare Ostracoda. Exposed. 2 feet

STRATIGRAPHY

Middle Miocene formations.—Kirkwood formation consists typically of gray fine-grained marly sand with abundant shells and shell fragments; locally of fine sand, silt, and clay. The so-called Shiloh marl, from which samples were taken, is more accurately described as a fine-grained argillaceous fossiliferous sand. The reported thickness of the Kirkwood formation is 100 feet at the surface. Three divisions were seen in the marl pits by Whitfield (1894):

3. Dark brown or chocolate colored clay with fossils (underlying the Cohansey "glass sand")
2. Stony layer of gray marl with *Ostrea*

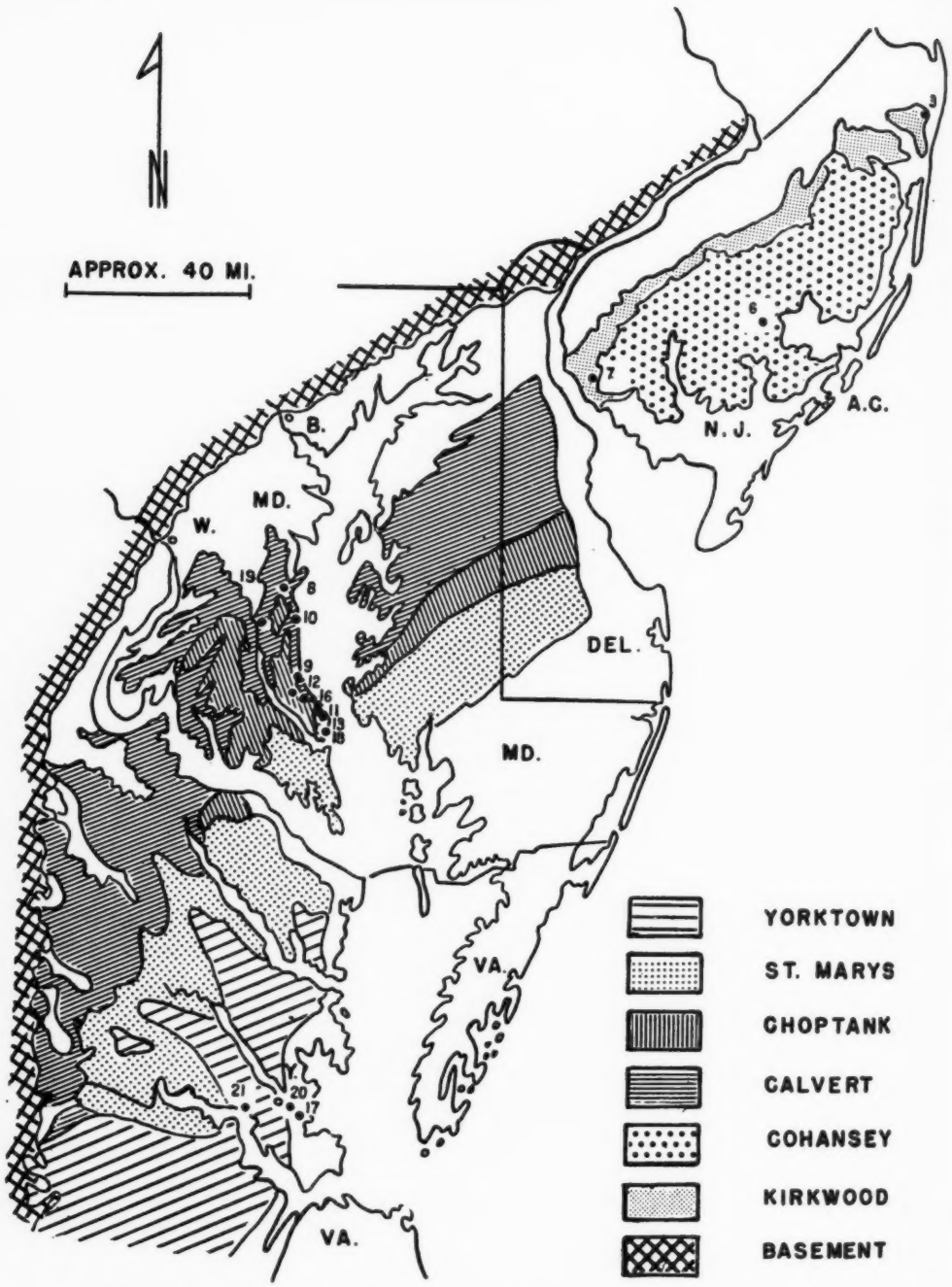

FIG. 1—Distribution of middle and upper Miocene formations; (Y, Yorktown; W, Washington; B, Baltimore; AC, Atlantic City). Collecting localities are designated by numbered dots.

1. Loose sandy gray marl with fossils.

The three lithologic types are still recognizable in the material that has been dug from the marl pits but only the lowest yielded a representative microfauna. The microfauna of the Kirkwood most closely resembles that of the Plum Point member of the Calvert formation. Diatoms are present in relatively small numbers in the material collected, but are abundant in subsurface samples from the Kirkwood. Twenty-seven species of Foraminifera and 15 species of Ostracoda were identified from Kirkwood samples.

Calvert formation is divided into two members with a total outcrop thickness of 310 feet (Shattuck, 1904). The Plum Point marl member (upper Calvert of Dryden, 1935), typically exposed at Plum Point, Calvert County, Maryland, consists of gray fossiliferous sandy marl, silt, sandy clay, with common to abundant Foraminifera and Ostracoda and rare to abundant diatoms. Diatoms are abundant in the lower part as high as Shattuck's zone 7. "Zones" numbered 4 through 15 by Shattuck are included in the Plum Point member. Most of them cannot be recognized as true paleontologic zones, as they are either nonfossiliferous or sparsely and erratically fossiliferous. Zones 4, 10, 12, and 14 may be actual molluscan faunizones corresponding to Harris' zones a, b, c, and d, respectively (Schoonover, 1941).

Fairhaven diatomaceous earth (lower Calvert of Dryden, 1935) consists of a buff-colored diatomaceous bed composed of silt, fossiliferous clay, and diatoms, that is 20 feet thick at the outcrop, and thick gray and white sparsely fossiliferous silt and sand beds. Shattuck's "zones" 1, 2, and 3 comprise the Fairhaven member; zone 2 may be a molluscan faunizone. Dryden (1935) substituted the designation "lower Calvert" for this member because the diatomaceous earth comprises only about one-ninth or less of the entire thickness of the pre-Plum Point beds. The diatomaceous zone increases to 350 feet in the subsurface in eastern Maryland (Richards, 1945), where it probably includes some of the highly diatomaceous lower Plum Point beds.

The oldest middle Miocene beds extend over a greater area in southern Maryland than do younger Miocene strata. Inland the upper part of the Calvert is absent (Dryden, 1935). The Calvert has an abundant and varied microfauna; it may represent deposition during the time of the greatest extent of the middle Miocene sea. From the Calvert samples, 40 species of Foraminifera were identified, of which 14 were not found higher in the section: *Bolivina marginata, B. marginata* var. *multicostata, B. subaenariensis, Bulimina gracilis, Buliminella elegantissima, Cassidulina crassa, Discorbis orbicularis, D. valvulata, Elphidium sagrum, Loxostomum gunteri, Nonion subgrateloupi, Pseudopolymorphina striata, Uvigerina* sp. cf. *U. pygmaea, Virgulina pontoni.*

The ostracod fauna of the Calvert samples includes 18 species, of which seven were not found in higher beds: *Clithrocytheridea diagonalis, Cytheretta inaequivalvis, C. plebia, Cytheropteron* sp., *Trachyleberis clarkana, T. dorsicornis, T. evax.*

Choptank formation consists predominantly of gray and yellow argillaceous fossiliferous silt and sand, and fine-grained marly sand, with a maximum thickness of 100 feet at the outcrop. The unconformity alleged to exist between the Choptank and Calvert formations (Shattuck, 1904) was not recognized in the collected sections. Diatoms are present in small numbers; Foraminifera and Ostracoda, as well as Mollusca, are relatively abundant, but the microfauna is not as rich in species as the microfauna of the Yorktown and the Calvert. Of 24 foraminiferal species identified in the samples, *Bulimina ovata* is the only one restricted to the Choptank in this section; three species, *Cancris sagra, Discorbis candeiana,* and *Eponides mansfieldi,* were not found below the Choptank; eight species, *Discorbis floridana, Lagena* sp., *Nonionella miocenica, Pulvinulinella pontoni, Spiroplectammina gracilis, Textularia gramen, Pyrulina albatrossi,* and *Virgulina miocenica,* were absent from higher beds.

Sixteen species of Ostracoda were identified from the samples, of which *Cytherura coryelli* and *Hemicythere punctistriata* are restricted to this formation; *Leguminocythereis whitei* and *Campylocythere laevissima* do not occur below the Choptank; and five species were not found higher in the section: *Clithrocytheridea diagonalis, Cytherideis sub-*

aequalis, *Haplocytheridea subovata*, *Paracytheridea shattucki*, and *Trachyleberis exanthemata*.

The Choptank formation was divided into "zones" numbered 16, 17, 18, 19, and 20 by Shattuck (1904), of which zones 17 and 19 are well-defined molluscan faunizones, corresponding to Harris' (1893) zones e and f (Schoonover, 1941).

St. Marys formation consists of gray and yellow argillaceous sand and sandy clay with several prominent beds of shell marl. Its reported maximum thickness is 150 feet at the outcrop (Shattuck, 1904). Diatoms are generally absent, and the microfauna is poor in both species and individuals. No Ostracoda were found in the samples except a fragment of *Trachyleberis* cf. *T. gunteri*. Eight species of Foraminifera were identified in the St. Marys samples. *Eponides mansfieldi* is more abundant than in samples from other beds.

This formation includes "zones" numbered 21, 22, 23, and 24 of Shattuck (1904). Of these, 22 and 24 are fossiliferous and may approximate true molluscan faunizones; zone 22 may correspond to Harris' (1893) zone g (Schoonover, 1941).

Upper Miocene formations.—The Cohansey formation consists of gray and yellow medium to fine-grained subangular to rounded quartz sand with phosphatic pellets and irregularly distributed bands of clay and argillaceous sand. Its thickness is estimated to range from 0 to 450 feet. It is nonmarine in origin, nonfossiliferous, and is included here for completeness of the record. Although the Cohansey formation is classified as upper Miocene, it is probably a diachronic facies including beds of middle and late Miocene age.

The Yorktown formation consists of as much as 125 feet of richly fossiliferous glauconitic sand, calcareous clay, sandy marl or marly sand, shell marl, and coquina (Roberts, 1932). Some of the calcareous beds are indurated to sandy limestone. Crossbedded hydrocalcarenites are exposed near Yorktown, Virginia. Lithologically, the Yorktown formation is distinguished from older Miocene strata by the presence of considerable glauconite and by its generally more calcareous nature. Paleontologically, it is also distinct, because it has an assemblage of Foraminifera and Ostracoda that contains species that do not range below the upper Miocene in the outcrop area. Of 27 species of Foraminifera found in the Yorktown samples, 10 species do not extend below the Yorktown: *Discorbis consobrina*, *D.* cf. *D. assulata*, *Elphidium* sp., *Eponides* aff. *E. mansfieldi*, *E.* sp., *Nonion granosum*, *N.* aff. *N. pizzarense*, *Planulina depressa*, *Textularia articulata*, *T. mayori*. Of 30 species of Ostracoda in these samples, 22 were not found below the Yorktown: *Anomocytheridea floridana*, *Campylocythere laeva*, *Clithrocytheridea virginiensis*, *Cytherideis agricola*, *C. rugipustulosa*, *C. ulrichi*, *C. echolsae*, *Cytherura elongata*, *C. forulata*, *C. wardensis*, *Eocytheropteron yorktownensis*, *Hemicythere conradi*, *H. schmidtae*, *Loxoconcha subrhomboidea*, *Favella rugipunctata*, *Paracytheridea mucra*, *P. vandenboldi*, *P. shattucki curta*, *Trachyleberis gomillionensis*, *T. vaughani*, *Paracytheridea similis*, *Bairdia* spp.

Mansfield (1929, 1943) proposed a zonation of the Yorktown based upon the molluscan fauna:

Zone 2 (above): *Turritella alticostata* zone
Zone 1: *Pecten clintonensis* zone.

The zones were further subdivided (Stephenson, 1933; Mansfield, 1943) but the smaller divisions appear to have only local validity. The fossil content of the beds varies considerably from place to place along the cliffs, and also changes as new material is exposed by wave action. The part of the formation exposed at and near Yorktown (locality 17, 20) represents approximately Mansfield's upper zone; the part exposed along James River (locality 21), approximately the lower zone.

The Yorktown formation is transgressive, overlapping unconformably upon older Miocene and pre-Miocene beds (fig. 2).

Zonation.—The formational units established by Clark and Miller (1912) and Shattuck (1904) are not easily recognizable because they are not lithologically distinct. Certain assemblages of Mollusca (Schoonover, 1941) are characteristic of certain parts of each formational unit, but away from the type localities, or in the subsurface, it is difficult to distinguish the Miocene formations from each other. Most of the so-called zones of Shattuck are not true

zones according to Oppel's concept that a zone is defined by its faunal association, as Schoonover has already pointed out. Furthermore, many of the zones cannot be recognized even at their type locality, and beds cannot be traced inland from the Chesapeake exposures.

All of the formations except the continental Cohansey sand have closely similar biofacies but can nevertheless be differentiated by their fossil assemblages. The changes in faunal assemblages coincide closely with the formation boundaries. Because the fossils are apparently not facies fossils, the faunal changes appear to reflect at least local variations in the sedimentary history. Since approximate time equivalency can thus be demonstrated in different lithologic facies (see fig. 2), these stratigraphic divisions may therefore be regarded as time-rock units, and as such, should be named. As they are not demonstrably units of first rank, they are tentatively designated substages. Additional data may permit raising them to the rank of stages. The Calvertian, Choptankian, St. Marysan, and Yorktownian substages contain all sediments deposited in the central Atlantic Coastal Plain Province during the times of accumulation, respectively, of the Calvert, Choptank, St. Marys, and Yorktown formations. Type exposures of these units are considered exemplary of the substages. Calvertian, Choptankian, St. Marysan, and Yorktownian substages embrace all time involved in the deposition of these deposits (Moore, 1947, 1948; American Commission on Stratigraphic Nomenclature, 1948a, 1948b, 1952).

On the basis of microfaunal assemblages, stratigraphic zonation (see Kleinpell, 1938) of the substages can be set up as follows:

Upper Miocene

Yorktownian substage
Hemicythere conradi zone
Hemicythere schmidtae zone

Middle Miocene

St. Marysan substage
Eponides mansfieldi zone

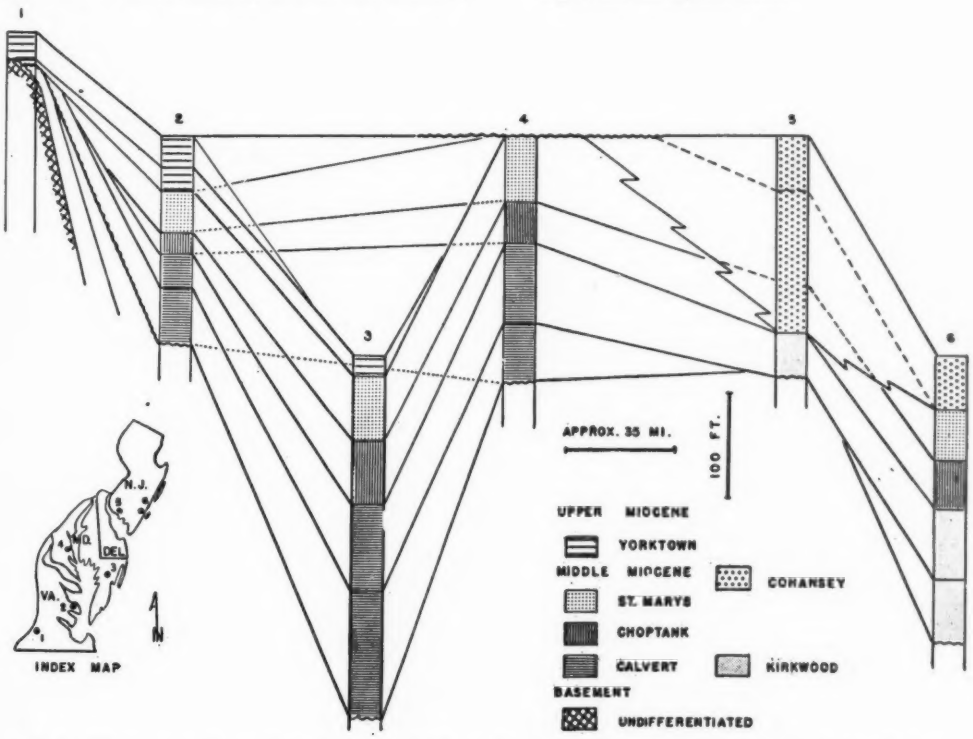

FIG. 2—Diagrammatic section showing middle and upper Miocene stratigraphy and correlation.

Choptankian substage
Cytherura coryelli zone
Calvertian substage
Trachyleberis exanthemata zone
Clithrocytheridea diagonalis zone

The zones outlined are faunizones (*Faunenzone*, Diener, 1929; faunizone, Arkell, 1933; Moore, 1948) based on faunal assemblages. The *Hemicythere conradi* zone, comprising the Yorktownian on York River in the vicinity of Yorktown, Virginia (see range chart, samples VA-3, VA-12, VA-2, VA-10, VA-17 from localities 17 and 20), includes common or abundant *Hemicythere conradi*, *Trachyleberis martini*, *Cytherideis ashermani*, in addition to other less abundant species listed on the chart. The *Hemicythere schmidtae* zone, comprising the lower Yorktownian on James River, Virginia (see range chart, samples VA-5, VA-6, VA-8, VA-11, VA-9, VA-4, VA-7 from locality 21), includes common or abundant *Hemicythere schmidtae* and fairly common *Anomocytheridea floridana*, *Trachyleberis gomillionensis*, as well as the less common species shown on the chart. The *Eponides mansfieldi* zone contains rare fossils, as shown on the range chart (sample MD-18 from locality 18) but fairly common *Eponides mansfieldi*. It represents all of the St. Marysan substage so far as is known. The *Cytherura coryelli* zone, comprising all the Choptankian substage, includes abundant *Cytherura coryelli*, abundant *Cytherideis ashermani* and common *Haplocytheridea subovata* as well as less common species such as *Campylocythere laevissima*, *Hemicythere punctistriata* (samples MD-14-6, MD-14-5, MD-14-1, MD-14-4 from locality 11).

The *Trachyleberis exanthemata* zone includes all of the Calvertian above "zone 7" of Shattuck, (samples MD-13-6, MD-13-5, MD-12-1, from localities 9 and 10). It is characterized by common *Trachyleberis exanthemata*, *T. evax*, *Cytheretta burnsi*, *Cytherideis ashermani*. The *Clithrocytheridea diagonalis* zone includes the lower part of the Calvertian substage, "zones 1 to 7" of Shattuck (samples MD-13-3, MD-13-4, MD-13-8, MD-13-7 from locality 10). Its faunal assemblage is similar to that of the next higher zone in its rare elements; it has common *Clithrocytheridea diagonalis* and *Trachyleberis radiata*, lacks *Cytheretta burnsi*, *Trachyleberis evax*.

Within each faunizone, or overlapping zones, selected teilzones (based on local range of individual species) can be delineated from the range charts. The significance of teilzones is valid only for local correlation because they are based on local range rather than total known range of individual species. The following teilzones coincide with faunizone boundaries:

Hemicythere conradi zone: *Paracytheridea similis*, *Cytherura forulata*, *C. wardensis*, *C. elongata*, *Cytherideis echolsae*, *Favella rugipunctata* teilzones.
Hemicythere schmidtae zone: *Trachyleberis vaughani* teilzone
Cytherura coryelli zone: *Cytherura coryelli*, *Hemicythere punctistriata*, *Paracytheridea shattucki* teilzones.
Trachyleberis exanthemata zone: *Trachyleberis evax*, *T. dorsicornis*, *T. marylandica* teilzones.
Clithrocytheridea diagonalis zone: no teilzones.

Recognition of the epibole (acme) of selected species is possible also from the range charts. Epiboles may be highly significant in local correlation, especially where no drastic ecologic differences exist between the two sections to be correlated. They may be the only criterion of correlation available in a section of continuous deposition where no marked differences in faunal assemblages are apparent. Epiboles of selected Miocene Ostracoda are given below:

Epibole (acme) of:

Hemicythere conradi	middle of *Hemicythere conradi* zone
Eocytheropteron yorktownensis	base of *Hemicythere conradi* zone
Anomocytheridea floridana	top of *Hemicythere schmidtae* zone
Leguminocythereis whitei	top of *Hemicythere schmidtae* zone
Cytheretta burnsi	top of *Trachyleberis exanthemata* zone
Trachyleberis martini	*Hemicythere conradi* zone
Cytherideis ashermani	*Cytherura coryelli* zone
Hemicythere schmidtae	upper half of *Hemicythere schmidtae* zone
Cytherura coryelli	*Cytherura coryelli* zone
Haplocytheridea subovata	*Cytherura coryelli* zone
Trachyleberis exanthemata	top of *Trachyleberis exanthemata* zone
Clithrocytheridea diagonalis	base of *Clithrocytheridea diagonalis* zone
Trachyleberis evax	top of *Trachyleberis exanthemata* zone

TABLE 1.—DISTRIBUTION OF OSTRACOD SPECIES

SPECIES	VA-10 Yorktown	VA- 2 Yorktown	VA- 3 Yorktown	VA-12 Yorktown	VA-17 Yorktown	VA- 7 Yorktown	VA- 4 Yorktown	VA- 9 Yorktown	VA-11 Yorktown	VA- 8 Yorktown	VA- 6 Yorktown	VA- 5 Yorktown	MD-18 St. Marys	MD-14-6 Choptank	MD-14-5 Choptank	NJ-9 Kirkwood	MD-14-1 Calvert	MD-14-4 Calvert	MD-12-1 Calvert	MD-13-5 Calvert	MD-13-6 Calvert	MD-13-3 Calvert	MD-13-4 Calvert	MD-13-9 Calvert	MD-13-7 Calvert
Paracytheridea similis	/	*	/	/	/	*	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Cytherura forulata	*	/	/	*	*	*	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Cytherideis echolsae	*	/	*	/	*	*	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Bairdia spp.	*	*	*	/	*	*	*	*	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Cytherideis rugipustulosa	*	*	/	/	*	/	*	*	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Cytherideis subaequalis ulrichi	*	/	/	/	/	/	*	*	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Eocytheropteron yorktownensis	/	/	/	X	/	/	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Hemicythere conradi	X	O	O	X	/	*	*	/	*	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Cytherideis agricola	*	*	/	/	/	*	*	*	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Clithrocytheridea virginiensis	*	*	/	*	*	/	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Anomocytheridea floridana	*	*	*	/	/	X	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Paracytheridea shattucki curta	*	*	/	/	/	/	/	/	/	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/
Leguminocythereis whitei	*	*	*	*	/	*	X	/	*	*	/	*		/	/	/	/	/	/	/	/	/	/	/	/
Campylocythere laevissima	*	/	*	X	/	*	/	/	*	*	/	*		/	X	/	/	/	/	/	/	/	/	/	/
Cytheretta burnsi	*		*	/	*	*	/	/	/	/	/	/		/	/	X	/	/	/	/	/	/	/	/	/
Trachyleberis martini	/	X	X	X	/	/	/	/	/	/	/	/		/	/	/	X	/	/	/	/	/	/	/	*
Loxoconcha reticularis	/	/	*	/	/	/	*	/	/	/	/	*		/	/	*	/	/	/	/	/	/	/	/	
Cytherideis ashermani	X	X	X	X	X	X	X	/	*	*	/			O	O	X	X	X	/	/	*	X		X	/
Cytheromorpha warneri		*	*	*	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Loxoconcha subrhomboidea		/	*	*	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Campylocythere laeva		/	*	/	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Favella rugipunctata			*	*	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Cytherura wardensis			*	*	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Cytherura elongata			*	*	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Trachyleberis gomillionensis			*	*	*	/	/	/	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Paracytheridea mucra				*	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Paracytheridea vandenboldi				*	*	*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Hemicythere schmidtae				*		X	X	X	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Trachyleberis vaughani						*	*	*	*	*	*	*		*	/	*	*	*	/	/	*	*		*	
Pterygocythereis americana							*	*						*		/	*			*		*		*	/
Trachyleberis gunteri													*												
Cytherura coryelli														X	O									/	
Hemicythere punctistriata														*	*	*									
Paracytheridea shattucki														*	*										
Haplocytheridea subovata														X	X	/	/		*	/		/			*
Cytherideis subaequalis														/	/					*		*			
Trachyleberis exanthemata														*	*	X	X		*	/	/	/			
Clithrocytheridea diagonalis														*	*	/	/		*	*		*		X	
Eucythere sp.															*	/	/								
Cytheretta plebia																/	/		*	*				/	*
Trachyleberis radiata																X	/				*	X			
Trachyleberis dorsicornis																/	*			*					
Trachyleberis evax																*	X	*							
Cytheropteron sp.																*	*				*	*			
Trachyleberis clarkana																								/	
Trachyleberis marylandica																									
Cytheretta inaequivalvis																									

* =rare (1–3 specimens); / =fairly common (4–8 specimens); X =common (9–16 specimens); O =abundant (more than 16 specimens).

TABLE 2.—DISTRIBUTION OF FORAMINIFERAL SPECIES

SPECIES	VA-10 Yorktown	VA- 2 Yorktown	VA- 3 Yorktown	VA-12 Yorktown	VA- 7 Yorktown	VA- 4 Yorktown	VA- 9 Yorktown	VA-11 Yorktown	VA- 8 Yorktown	VA- 6 Yorktown	VA- 5 Yorktown	MD-18 St. Marys	MD-14-6 Choptank	MD-14-5 Choptank	NJ-9 Kirkwood	MD-14-1 Calvert	MD-14-4 Calvert	MD-12-1 Calvert	MD-13-5 Calvert	MD-13-6 Calvert	MD-13-3 Calvert	MD-13-4 Calvert	MD-13-8 Calvert	MD-13-7 Calvert	MD-3 Calvert
Elphidium cf. E. incertum	*	*																							
Elphidium sp. (papillose)	/	/	/	/																					
Nonion granosum	X	X	X	X																					
Textularia mayori	X	X	/	X																					
Eponides repandus (?)	/	/	*	*	?		/			*															
Eponides mansfieldi	*	?	*	/	/		/	/				X													
Discorbis consobrina	*		X	*	*	*			/	*		*	*		*										
Discorbis candeiana	X	X	X	/	*	*				*			/												
Textularia articulata	*	X	/	/	*	*	*		*	*				*											
Cibicides concentricus	○	○	○	○	X	X	○	X	/	X	*														
Cibicides americanus	*	○	/	X	○	○	/	/	*	/	/														
Cibicides lobatulus		*	*	*	*	/	/	/	*	*			X	/	X	X		X	/						
Nonion pizzarense		*	/	/	/	X	X	*	*	/		*	/	/	X	X	*	/	X	X	X				
Cancris sagra		*	*		*	*	/		*	X	*		*	/	X	X	*	X	*	X	/	*	O	/	
Eponides aff. E. mansfieldi		*		*	?	*	?		*	/	*		*	/	/	/		/		/					
Discorbis aff. D. assulata		*	/				*			*															
Rotalia bassleri			*	*			*																		
Uvigerina sp. (costate)			*																						
Buliminella curta				*																					
Quinqueloculina sp.					*	*	*	*	*		*														
Nonion aff. N. pizzarense					/	/																			
Cibicides floridanus						X	X	*	*	X															
Globulina gibba						*																			
Nonion incisum						*																			
Planulina depressa						*	*																		
Elphidium poeyanum																									
Elphidium incertum																									
Textularia gramen																									
Textularia agglutinans																									
Valvulineria floridana																									
Textularia spp. indet.																									
Triloculina sp.																									
Bulimina ovata																									
Pseudopolymorphina sp.																									
Virgulina miocenica																									
Spiroplectammina gracilis																									
Lagena sp.																									
Nonionella miocenica																									
Discorbis floridana																									
Bolivina subaenariensis																									
Robulus sp.																									
Pyrulina albatrossi																									
Virgulina pontoni																									
Bolivina marginata																									
Loxostomum gunteri																									
Bolivina paula																									
Guttulina problema																									
Angulogerina occidentalis																									
Pseudopolymorphina striata																									
Buliminella elegantissima																									
Discorbis valvulata																									
Pulvinulinella pontoni																									
Uvigerina sp.																									
Bulimina gracilis																									
Discorbis orbicularis																									
Nonion subgrateloupi																									
Sigmoidella kagaensis																									
Bolivina marginata var.																									
Nodogenerina sp.																									

* =rare; / =fairly common; X =common; ○ =abundant (estimated abundance).

Correlation.—Because the environment of deposition of the several Miocene stages appears to be similar, and because the biofacies are also similar, a comparison of the faunas should provide stratigraphic correlation between synchronous beds, without the complication of diachronic facies. A study of the Kirkwood assemblage shows that it is closest in character to that of the *Trachyleberis exanthemata* zone of the Calvertian substage, containing all but four of the ostracod species found in that zone, including *Cytheropteron* sp., *Trachyleberis evax*, and *T. dorsicornis* which are limited to that zone. The abundance of *Cytheretta burnsi* and *Trachyleberis exanthemata* in the Kirkwood coincides with the epiboles of those species in the upper zone of the Calvertian substage. In addition to those species the Kirkwood fauna includes also common *Cytherideis ashermani* and *Trachyleberis radiata*.

The Cohansey formation is nonfossiliferous, and is believed from subsurface evidence to be a diachronic sand lithotope, representing nonmarine deposition during the Choptankian, St. Marysan, and Yorktownian (fig. 2).

Ostracoda described from the Duplin marl of North Carolina (Edwards, 1944) and from the Choctawhatchee formation of Florida (Howe, 1935) are similar to Yorktownian assemblages. Differences in the faunules may be attributed to ecologic or facies differences.

The Miocene Ostracoda described from Cuba and Guatemala by Van den Bold (1946) include 14 species identical with or very similar to those in Maryland and Virginia. The Miocene fauna of Panama (Coryell and Fields, 1937), however, contains only two of the same species, although it is approximately the same age as the Yorktownian substage.

Paleoecology.—Paleontologists are increasingly aware that a fossil fauna has significance other than as a criterion of correlation; that indeed, unless it is evaluated and tested in the light of its other meanings, a fauna is of uncertain value in correlation. One of the most important uses of a fossil fauna is as an indicator of ecology; without interpreting the ecology of a fauna it may be difficult to determine whether it is a facies fauna or a stratigraphic index. Synchronous faunas from different environments are often less alike than non-synchronous faunas from similar environments. Ecologic interpretations are essential to deciphering the geologic history of an area. It is necessary, therefore, to analyze a fauna with a view to gaining as much information as possible concerning the environment in which it lived. The problem is at once complicated by the fact that the thanatocoenosis is not the same as the biocoenosis that inhabited a given area at a given time, although it may be that "the assumption that a fossil fauna is fairly representative of the fauna as it lived does not seem to lead to serious error" (Davies, 1934). Fossil benthos faunules are thanatocoenoses that are modified from biocoenoses by factors such as waves, currents, chemical action, and by the drifting or transporting of allochthonous elements into the assemblage. This fact accounts for some of the apparent anomalies in fossil faunas that may, for example, contain a mixture of neritic and brackish water forms. Many collections of Recent benthos represent, similarly, thanatocoenoses. Nevertheless, it is possible to interpret the conditions of the biotope in which fossil forms lived by comparison with the biotope of similar Recent forms.

Although relatively few papers that deal specifically with ecology of Recent Ostracoda are available (Brady, 1880; Müller, 1894; Sars, 1928; Elofson, 1941; Triebel, 1941; Tressler, 1942; Van den Bold, 1946), data regarding occurrences of many species are included in systematic work. From these, certain generalizations can be made. Ostracoda are found in both marine and nonmarine environments. A large proportion of marine ostracod genera are benthonic; those that are nektonic swim close to the bottom. Some genera have planktonic larval stages. If the depth and temperature ranges of Recent species were better known they could therefore be used as reliable environment indicators. However, most of the species defined by workers in the past on Recent forms have limits much broader than the concepts of modern systematics allow. As such, they mistakenly appear to be eurybathic and show a wide range of temperature adaptation. When species are more

accurately defined their value as environment indicators can be more accurately ascertained. In general, well developed diversified marine ostracod faunas, mostly of the order Podocopa, are found in shallow open waters, above 150 meters (i.e., in the sublittoral, inner neritic, and middle neritic zones, within the euphotic zone). The diversity and abundance of the ostracod fauna decreases with increasing depth beyond the 200 meter line. A small number of individuals and species live below 500 fathoms. The genera *Cytheridea*, *Hemicythere*, and *Cytheropteron*, as Sars defined them, are found between 10 and 50 fathoms. No temperature limits can be stated, as species of the same genus inhabit arctic and tropical waters.

The abundance of Ostracoda relative to that of Foraminifera tends to increase with decrease in salinity. Some species live in low-oxygen environments and even in reducing environments.

The morphology of the shell is related to the habitat of the species (Triebel, 1941): thick-shelled carapaces suggest availability of large amounts of calcium carbonate; the number of tuberculate forms increases with decrease in salinity. (Tuberculations decrease specific weight of shell.) Smooth forms of the suborder Platycopa are generally deep-water benthonic genera. Deep-water forms may be thin-shelled, if there is a deficiency in calcium carbonate or in oxygen. Creeping forms have ventral alations; swimming forms are more symmetrical than crawling forms; vertical furrows are related to the musculature, and therefore possibly to the ecologic conditions that involve use of the musculature.

Conclusions from the Ostracoda regarding the paleoecology of the Miocene are general because published ecological data on Recent ostracods are not specific enough to indicate depth, temperature, and salinity changes within narrow limits. Unpublished data by W. T. Rothwell, Jr., on distribution of ostracods in the Gulf of Mexico show predominant occurrences of *Hemicythere*, *Trachyleberis* (certain species only), *Pterygocythereis*, *Cytherideis*, and "*Cytheridea*" (sensu lato) in two biofacies. Most of the common occurrences of species of these genera are found in the continental shelf, at depths between 35 and 190 meters.

The Miocene Ostracoda of this study indicate a marine sublittoral to middle neritic environment, probably waters less than 150 meters in depth, of average salinity (35‰) and average calcium carbonate content. The deposits of the Choptankian substage may represent less saline waters than those of the Calvertian substage because the proportion of Ostracoda to Foraminifera is greater in the Choptankian samples. Conditions during the St. Marysan were unfavorable for Ostracoda. The Yorktownian ecology, on the other hand, encouraged the existence of an abundant and varied fauna that indicates normal continental shelf environment. The presence in the Yorktownian of abundant relatively smooth forms, compared with the predominance of tuberculate forms in the Calvertian, may indicate more open sea conditions for the Yorktownian deposits, and slightly brackish or more restricted conditions for the Calvertian deposits, such as a broad open embayment. The Yorktownian assemblage is very similar to that of the Duplin (Edwards, 1944) and the Choctawhatchee (Howe, 1935); they represent deposition in similar environments and suggest that the Yorktownian fauna differs from that of the middle Miocene not only because of age difference but probably because the influence of the southern fauna was more strongly evident in the Yorktownian than previously.

Amplification of ecological interpretation can be made from the Foraminifera. Parker's (1948) work on the Foraminifera of the continental shelf from the Gulf of Maine to Maryland contains ecologic analyses of the faunas collected in six traverses across the shelf, and affords a basis of comparison for the Miocene faunas. She finds that the benthonic assemblages vary in four depth-temperature zones:

Zone 1: eulittoral and sublittoral, 0–15 meters depth, 0–27°C. temperature range.
Zone 2: inner neritic, 15–90 meters depth, 3–16°C. temperature range.
Zone 3: outer neritic, 90–300 meters depth, 9–13°C. temperature range. (This zone can be subdivided at about 150 meters.)
Zone 4: bathyal (continental slope), 300 to 1000 meters depth, 5–8°C. temperature range.

Charts (figs. 3, 4) show the percentage of each genus in each depth-temperature zone. Similar charts (figs. 5, 6) show per-

centage of each genus in the Miocene formations.

Comparison of the percentage distribution of the genera common to Miocene and Recent suggests that archibenthic forms and eulittoral forms are absent from the Miocene, and suggests some resemblance of the Miocene faunas to the Recent 90 to 150 meter faunas. However, the genera and indeed many of the same or related species, that are abundant in Miocene and rare in northern Atlantic waters (*Discorbis*, *Nonion*, *Eponides*, and *Textularia*) are found widely distributed in warmer Atlantic waters and in the Caribbean area, most abundantly at shallow depths of 5 to 40 fathoms (Cushman, 1918).

The Miocene sediments in this area may

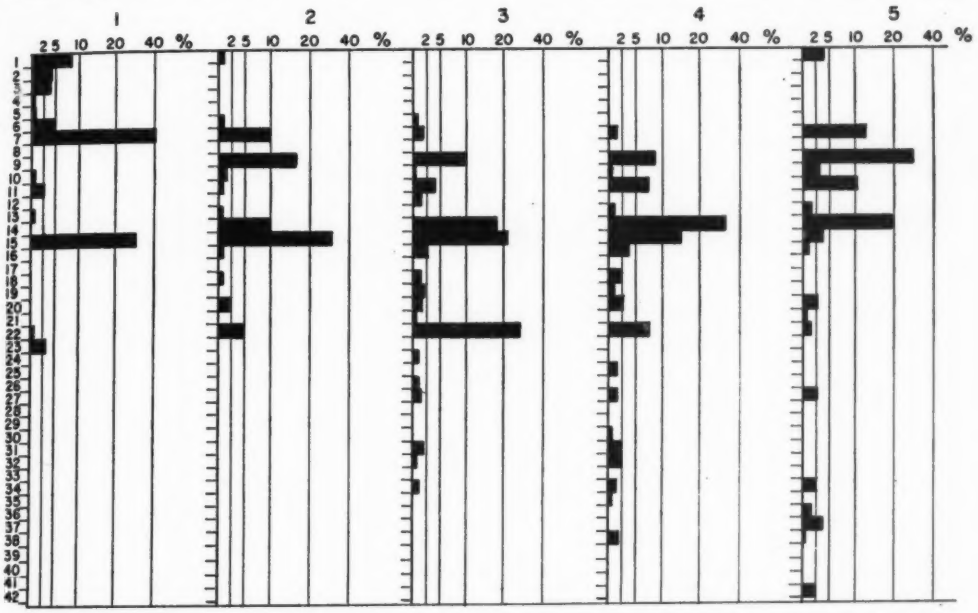

FIG. 3—Percentage distribution of Recent foraminiferal genera off New Jersey coast (compiled from Parker, 1948). 1 = 36 to 70 meters; 2 = 70 to 90 meters; 3 = 90 to 150 meters; 4 = 150 to 300 meters; 5 = below 300 meters.

KEY TO PERCENTAGE DISTRIBUTION CHARTS OF FORAMINIFERAL GENERA
(FIGS. 3, 4, 5 and 6.)

1 Proteonina
2 Eggerella
3 Quinqueloculina
4 Trochammina
5 Raphanulina (Globulina)
6 Guttulina
7 Elphidium
8 Buliminella
9 Bulimina
10 Virgulina
11 Bolivina
12 Discorbis (including some Valvulineria spp.)
13 Eponides
14 Cassidulina
15 Cibicides
16 Planulina
17 Pyrgo
18 Robulus
19 Marginulina
20 Lagenidae of various genera
21 Nonion
22 Angulogerina
23 Triloculina
24 Massilina
25 Lagena
26 Nonionella
27 Uvigerina
28 Entosolenia
29 Cancris
30 Pulvinulinella
31 Epistomina
32 Pseudoclavulina
33 Nodosaria
34 Desinobulimina
35 Cassidulinoides
36 Pullenia
37 Listerella
38 Gyroidina
39 Rotalia
40 Textularia
41 Sigmoidella
42 Valvulineria (deep water forms)

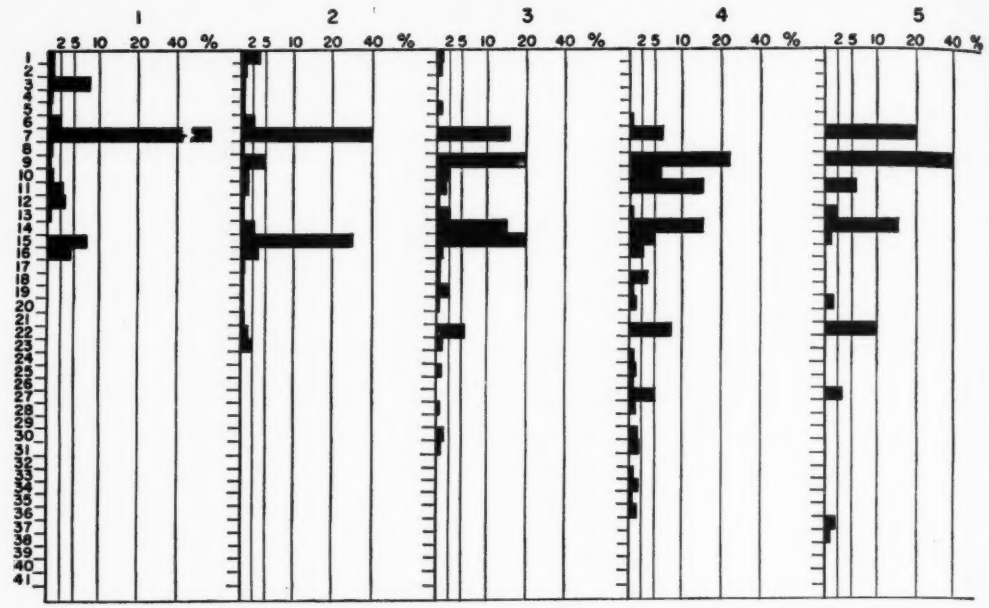

FIG. 4—Percentage distribution of Recent foraminiferal genera off Maryland coast (compiled from Parker, 1948). 1 = to 50 meters; 2 = 50 to 90 meters; 3 = 90 to 150 meters; 4 = 150 to 300 meters; 5 = below 300 meters.

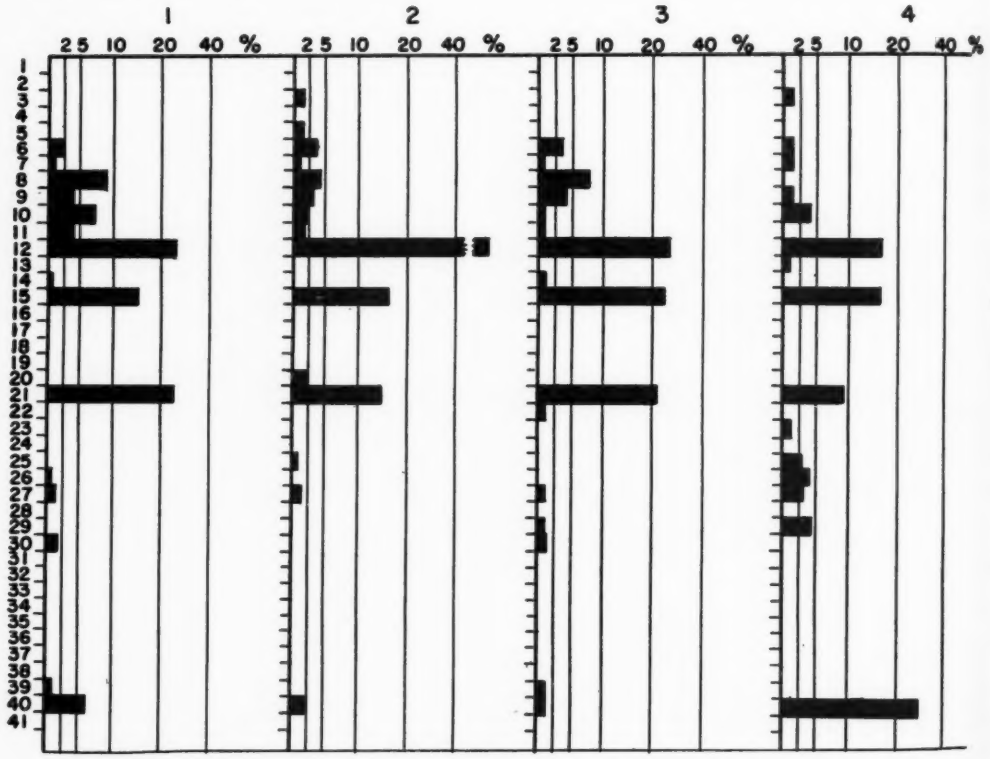

FIG. 5—Percentage distribution of Miocene foraminiferal genera. 1 = lower Calvertian; 2 = upper Calvertian; 3 = Kirkwood formation; 4 = Choptankian.

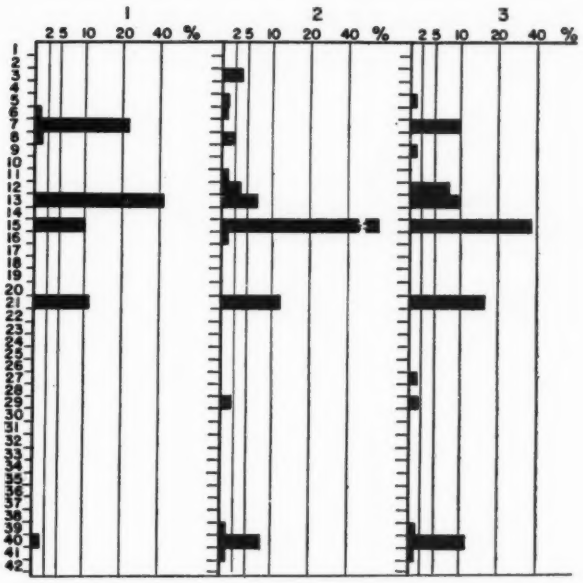

FIG. 6—Percentage distribution of Miocene foraminiferal genera. 1 = St. Marysan; 2 = lower Yorktownian; 3 = upper Yorktownian.

have been deposited in shallow, warm waters, similar to the Atlantic south of Cape Hatteras, and to the Caribbean Sea. Differences between the Miocene assemblages and Recent assemblages from all depths at the same latitude may be due to temperature differences.

Deposition could have taken place anywhere on the continental shelf. The predominance of marls, silts, and sandy clays indicates marine neritic deposition. No conclusions regarding depth of water or distance from shore can be drawn without a detailed comparative analysis. Conditions on the present shelf are extremely variable (Stetson, 1939). Cross-bedding in the hydrocalcarenites of the Yorktown deposits suggests that that part of the section is a eulittoral or sublittoral deposit. The sharp fragmentation and absence of wear on shell fragments gives little evidence of continued wave action or of extensive transportation of the organic components.

Absence of black shales and pyrite indicates open sea, oxidizing rather than reducing environment. Wide lateral extent of the formations also is indicative of deposition in an open sea rather than in lagoons and small bays. The waters probably varied from slightly muddy to clear, the turbidity affecting the abundance distribution and specific constitution of the faunas in the several stratigraphic units.

MORPHOLOGY AND TAXONOMY OF THE OSTRACODA

Hinge characters.—Almost all the Tertiary genera belong to the family Cytheridae, which is in the process of revision by several workers. In the following systematic treatment the Ostracoda are arranged according to hinge characters. The classification is modified from Zalanyi (1929) and Van den Bold (1946). Only those genera found in this study are considered, but other genera can be assigned to their proper positions according to their hinge characters. A further breakdown of the hinge groups could form the basis for the recognition of families or subfamilies. The terms apply only to the mature hinge.

Adont or *dysodont:* without teeth. Probably includes most Platycopa; no genera in present study.

Desmodont: longitudinal ridge or bar below dorsal margin of one valve; marked groove below dorsal margin of other valve. *Cytherideis.*

Taxodont: elongate serrate, crenulate, or denticulate dental area along most of length of hinge line; cardinal teeth and sockets may be differentiated, but are not so prominent as the taxodont median element. *Cytheropteron, Paracytheridea, Eocytheropteron, Clithrocytheridea, Haplocytheridea, Anomocytheridea.*

Crasidont: a term here introduced (derived from the Greek *krasis*, a mixture) for hingement that combines features of taxodont and heterodont dentition, in which the taxodont element is subordinate. *Leguminocythereis, Campylocythere, Loxoconcha* (?) (Tertiary species). Several genera, such as *Loxoconcha*, that are normally or characteristically heterodont, have a crasidont hinge in some stages of their phylogeny. Perhaps such genera should be subdivided.

Heterodont: strongly differentiated cardinal teeth and sockets, separated by smooth median bar and groove. *Cytheromorpha, Cytherura, Cytheretta, Trachyleberis, Hemicythere, Pterygocythereis, Favella.*

The cryptodont classification of Zalanyi appears to apply only to immature shells, in which the hinge structure is weak and primitive. Genera founded upon such hinge structure should be reviewed. It may be found that they all represent molt stages of genera that have a distinct hinge structure in their mature form. In cases where the immature hinge is of the "*Archicythereis*" type, found in young stages of most Tertiary Cytheridae, it is here termed *archidont*, indicating primitive or early dentition.

Variations.—Species of fossil ostracods are differentiated on the basis of morphologic characters such as strength of hinge, shape of carapace, surface lobation and ornamentation, line of concrescence and marginal area, muscle scars and shell furrows. These characters are related to the morphology of the animal (Triebel, 1941), and therefore they are useful taxonomic characters, although some of them may emphasize differences that are relatively insignificant biologically. Analysis of the Miocene ostracod fauna found in outcrop samples in New Jersey, Maryland, and Virginia indicates the presence of 47 species, belonging to 19 genera. No verifiable horizontal (lateral) or allopatric subspecies have been identified, because populations from other areas were not studied in detail. Some groups (possibly clines) that may be subspecies or allied to species or subspecies of the same age in other areas require further investigation. Vertical (allochronic) subspecies, however, are recognized and, with species, are used as a basis for stratigraphic zonation and correlation. Phenotypic variants are regarded as varieties, and are not given Linnaean names, in accordance with Newell's (1948) suggestion.

Molt stages.—Molt stages are inherent in the ontogeny of the individual ostracods, and the individual carapaces representing the several instars of an ostracod species should not be given taxonomic rank. LeRoy's method of denoting the stages of growth by the letters A, B, C, etc., seems satisfactory, with two possible objections: (1) some stages may remain undiscovered at the time of the original description, and (2) the letters lack uniformity of significance because of the difference in number of instars of different species. Despite these objections the writer has followed LeRoy's procedure.

The recognition of fossil molt stages is a matter of interpretation, but generalizations

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EXPLANATION OF PLATE 78

Magnifications approximately ×40.

FIGS. *1–13—Cytherideis ashermani* Ulrich and Bassler. *1, 2*, left valves, adult; *3*, right valve, molt; *4*, right valve, interior, molt; *5*, left valve, molt; *6*, left valve, molt; *7*, right valve; *8*, dorsal view; *9*, right valve, very young molt; *10*, left valve, adult; *11–13*, right valves. (p. 778)

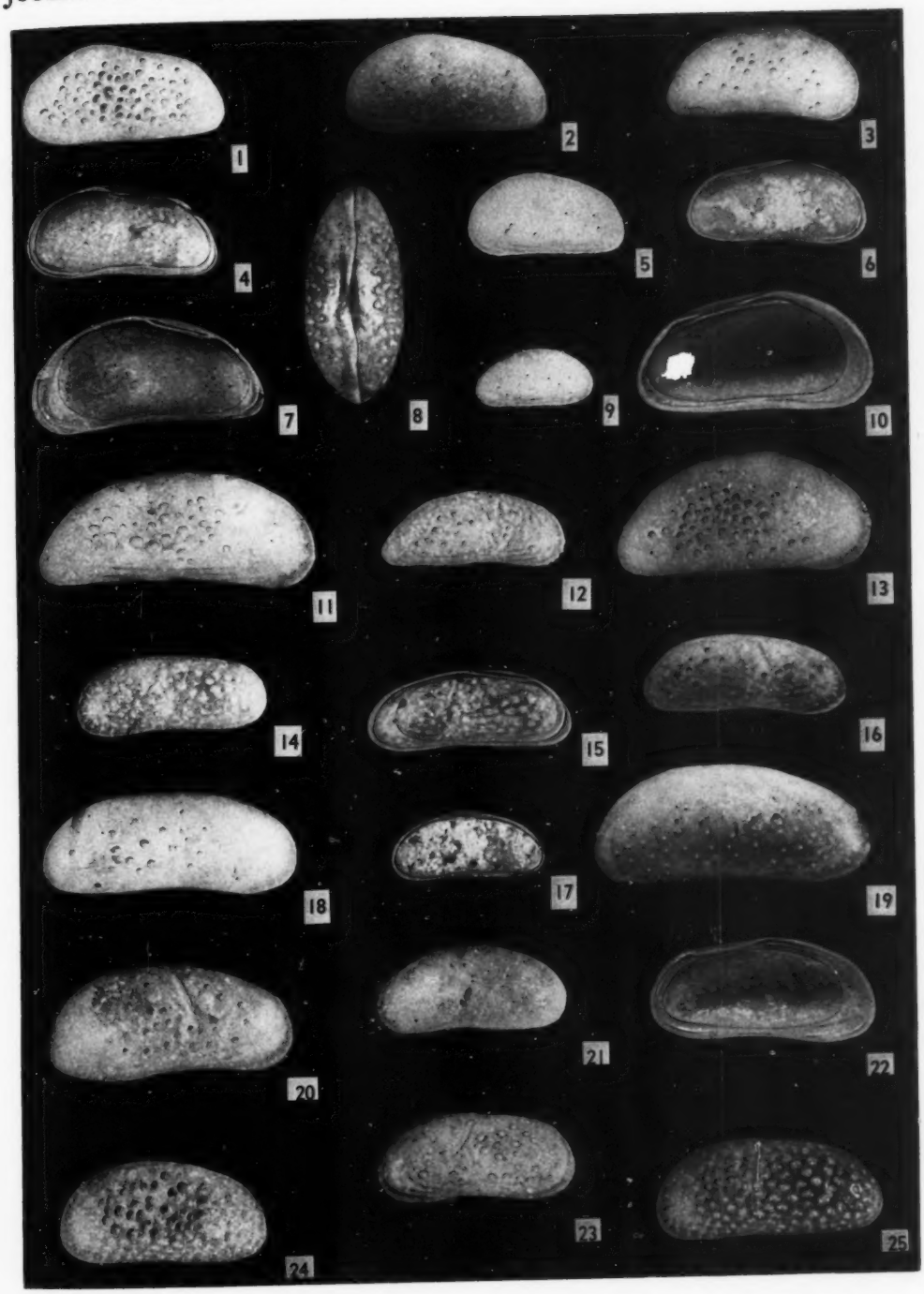
14–17—Cytherideis echolsae Malkin, n. sp. *14*, left valve; *15*, right valve, interior; *16*, right valve; *17*, left valve, interior, molt. (p. 778)

18, 21—Cytherideis subaequalis Ulrich and Bassler. (p. 779)

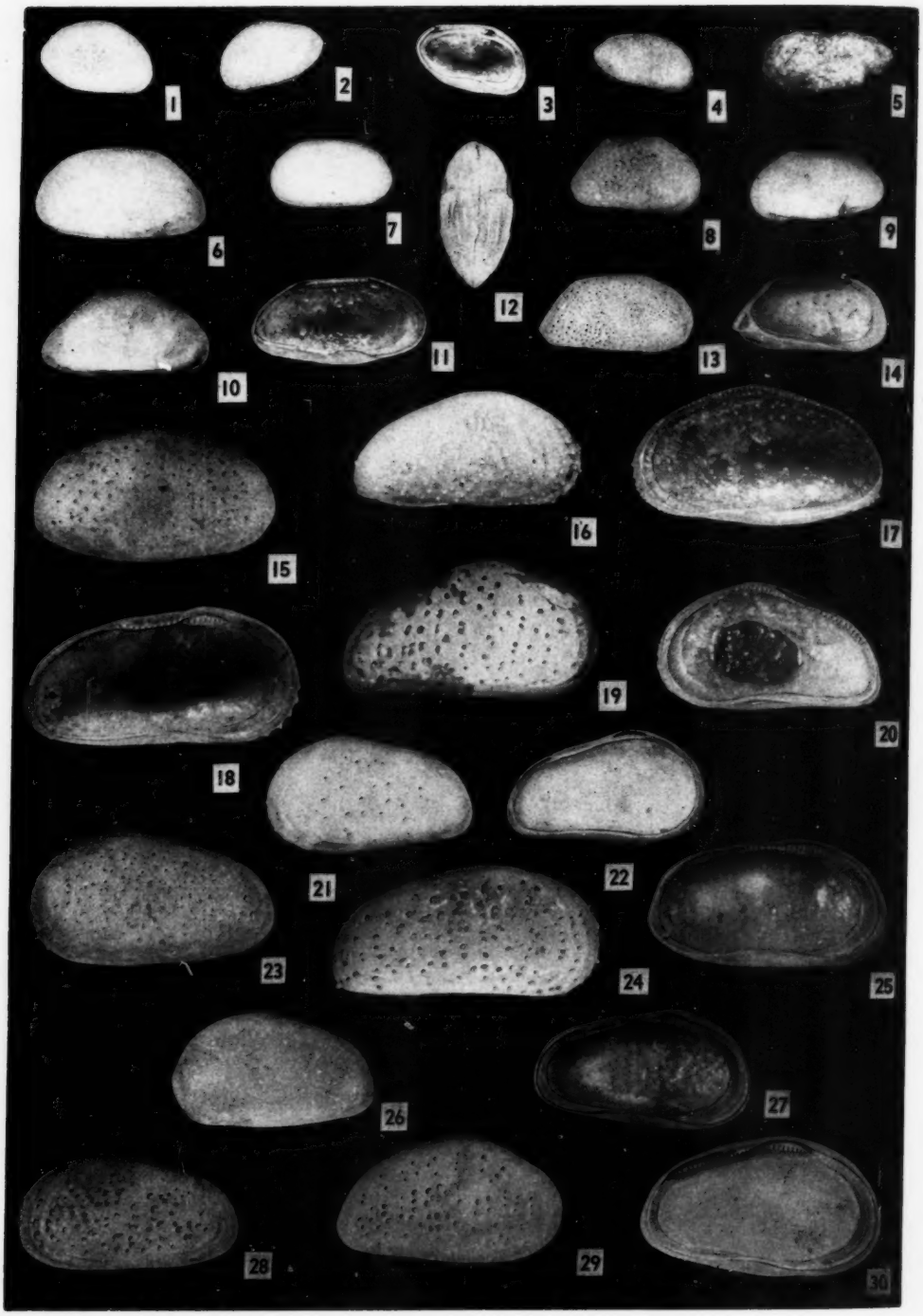
19—Cytherideis subaequalis ulrichi Howe and Johnson. (p. 779)

20, 22, 23—Cytherideis rugipustulosa Edwards. *20*, left valve; *22*, left valve, interior; *23*, right valve. (p. 780)

24, 25—Cytherideis agricola Howe and Hadley. Left valves. (p. 779)



Malkin, Miocene Ostracoda of New Jersey, Maryland, and Virginia



Malkin, Miocene Ostracoda of New Jersey, Maryland, and Virginia

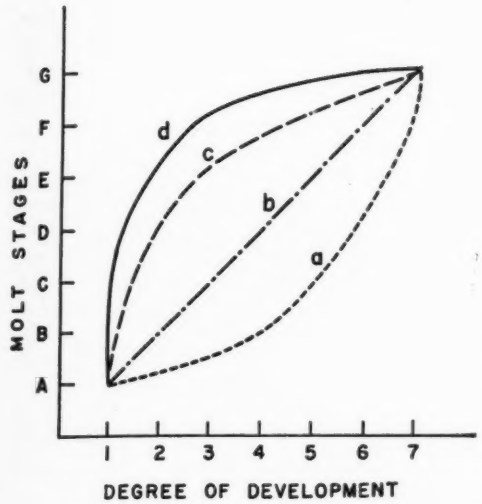


FIG. 7—Rate of development of morphologic features in ostracod molt stages. a = ornamentation; b = size; c = marginal area; d = hingement. 1, 2, 3, 4, 5, 6, 7 represent degrees of completeness of development increasing from 1, least development, to 7, most complete development.

concerning the change of morphologic characters during molt progress can be made, and are summarized in figure 7. The change in all species observed follows the pattern of the two species reported by LeRoy. The final complex hinge is the last character to mature, as would be expected, because the hinge must be relatively weak in order that the immature carapace be shed. The marginal area develops somewhat more rapidly than the hinge, and is found in almost mature development in one or two instars before the adult form. Size appears to change most regularly. Ornamentation is well developed in early stages, which can be recognized as molts by their weak hinges and slight marginal areas, or by weak hinge alone in advanced youthful stages. Early instars are thin-shelled and fragile; their shape is similar to that of the mature carapace.

In summary, the order of maturing of characters as shown in ostracod molts appears to be: (1) shape (not plotted); (2) ornamentation; (3) marginal area; (4) size and shell thickness; (5) hinge. Haeckel's biogenetic "law" is followed only in a very generalized way because the ontogeny, as shown by the molt stages, does not recapitulate the phylogeny as shown by specific or subspecific (evolutionary) changes. More precisely, early molts of late Miocene species are different and distinct from late molts or adults of the probably ancestral middle Miocene species. In a more general sense, however, the development of a phyletic group follows the ontogenetic development, for example, in the late appearance of a strong heterodont hinge.

EXPLANATION OF PLATE 79

Magnifications approximately ×40.

FIGS. *1–4—Eocytheropteron yorktownensis* Malkin, n. sp. *1, 4*, right valves; *2*, left valve; *3*, left valve, interior. (p. 780)

5—Paracytheridea vandenboldi Puri. (p. 780)

6–9—Paracytheridea shattucki (Ulrich and Bassler). *6, 9*, left valves; *7*, left valve, molt; *8*, right valve. (p. 780)

10–12—Paracytheridea shattucki curta Malkin, n. subsp. *10*, right valve; *11*, left valve, interior. *12*, ventral view. (p. 781)

13, 14—Paracytheridea similis Malkin, n. sp. *13*, right valve; *14*, left valve, interior. (p. 781)

15, 17—Haplocytheridea subovata (Ulrich and Bassler). *15*, left valve; *17*, right valve, interior. (p. 782)

16, 20—Haplocytheridea proboscidiale Edwards. *16*, right valve; *20*, right valve, interior. (p. 783)

18, 19, 21, 22, 24—Clithrocytheridea diagonalis Malkin, n. sp. *18*, left valve, interior; *19*, right valve, adult; *21*, left valve, molt (Form B); *22*, left valve, interior, molt; *24*, right valve, almost mature molt (Form C). (p. 782)

23, 25–28—Clithrocytheridea virginiensis Malkin, n. sp. *23, 28*, left valves; *25, 27*, left valves, interior; *26*, left valve, molt. (p. 783)

29, 30—Anomocytheridea floridana (Howe and Hough). *29*, right valve; *30*, left valve, interior. (p. 784)

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille
Suborder PODOCOPA Sars
Desmodont hinge group
Genus CYTHERIDEIS Jones, 1856
CYTHERIDEIS ASHERMANI Ulrich and Bassler
Plate 78, figures 1–13

Cytherideis ashermani ULRICH AND BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 126, pl. 37, figs. 10–16; HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 14, pl. 3, figs. 8–10; EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 514, pl. 86, figs. 1–4; SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 195, pl. 14, fig. 1; —, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 19.

Cytherideis longula ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 128, pl. 37, figs. 21–27; SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 195, pl. 14, fig. 2; —, 1951, U.S. Geol. Survey Prof. Paper 234-A, p. 19.

Cytherideis semicircularis ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 127, pl. 37, figs. 18–20.

Cytherideis cylindrica ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 126, pl. 37, fig. 17.

Remarks.—The characteristics of this species have been described by previous authors. Range of variation in length to height ratio is shown in figure 8, in which are indicated the ratios that apply to the several synonymous species that form a continuous series.

Molts lack hinge structure and broad marginal area, but are similar in outline. Youngest molts are smooth, thin-shelled, fragile, with very narrow marginal area; intermediate stages are fairly thick-shelled, finely to coarsely punctate, have narrow marginal areas and weak hinges.

Dimensions.—Length, 0.62 to 0.95 mm.; height, 0.31 to 0.44 mm.

Distribution.—Throughout middle and upper Miocene; figured specimens from samples MD-13-3, MD-14-1, MD-14-5, MD-14-6.

CYTHERIDEIS ECHOLSAE Malkin, n. sp.
Plate 78, figures 14–17

Description.—Mature carapace thick-shelled, elongate, compressed; dorsal margin low arcuate; ventral margin slightly incurved in anterior half; anterior broadly rounded; posterior much more sharply rounded, extended. Height similar through-

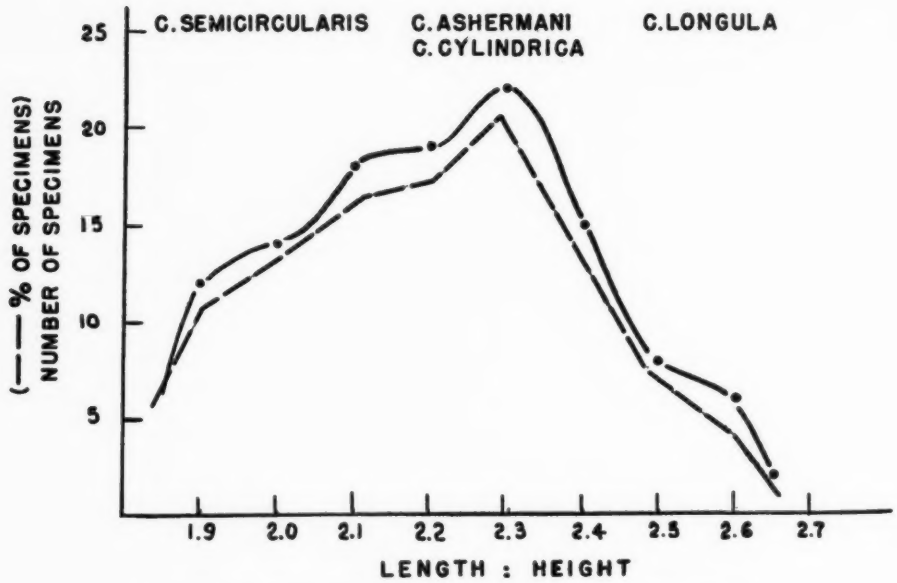


FIG. 8—Continuous variation of characteristics of *Cytherideis ashermani* and synonymous species.

out, about one-third the length. Anterior and posterior bordered by compressed clear area. Surface marked with coarse angular pits; narrow curved vertical premedian sulcus.

Interior shallow; marginal area broad with prominent sharp raised lip in right valve that fits into sharp groove inside of free margins of left valve. Dentition desmodont, as in *Cytherideis*, but with high tooth-like projection on anterior end of posterior dental ridge.

Diagnosis.—Differs from *C. ashermani* in proportions, ornamentation, more pronounced lip and groove around margins; more developed hinge.

Dimensions.—Length, 0.69 to 0.74 mm.; height, 0.29 to 0.31 mm.

Distribution.—Upper Yorktownian; cotypes from sample VA-12.

CYTHERIDEIS SUBAEQUALIS Ulrich and Bassler
Plate 78, figures 18, 21

Cytherideis subaequalis ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 127, pl. 37, fig. 28.

Diagnosis.—Although this species falls within the length to height ratio limits of *C. ashermani*, it is distinguished by the fact that the height at both cardinal angles is the same, as shown in figure 9. In this respect it is similar to *C. ulrichi* from which it differs only in size and convexity of valves.

Dimensions.—Length, 0.87 to 0.90 mm.; height, 0.35 to 0.37 mm.

Distribution.—Calvertian and Choptankian; figured specimens from samples MD-13-8, MD-14-1.

CYTHERIDEIS SUBAEQUALIS ULRICHI Howe and Johnson
Plate 78, figure 19

Cytherideis ulrichi HOWE and JOHNSON, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 16, pl. 3, figs. 11–14.

Diagnosis.—Because these individuals differ from *C. subaequalis* only in greater size and convexity of valves they are tentatively regarded as an allochronic subspecies of that species (see fig. 9).

Molts are thin valves, similar in outline, lacking hinge, with narrow marginal area.

Dimensions.—Length, 1.01 to 1.05 mm.; height, 0.45 to 0.48 mm.

Distribution.—Yorktownian; figured specimen from sample VA-2.

CYTHERIDEIS AGRICOLA Howe and Hadley
Plate 78, figures 24, 25

Cytherideis agricola HOWE and HADLEY, 1935,

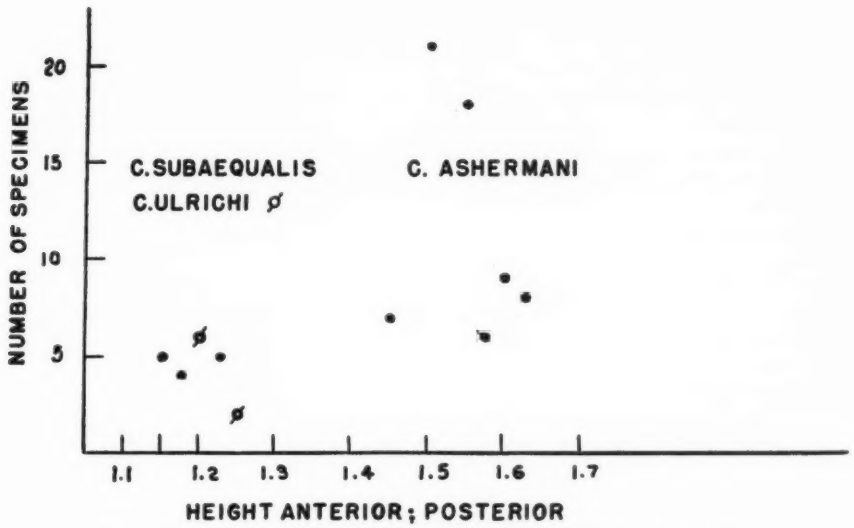


FIG. 9—Relation of *Cytherideis ashermani, Cytherideis subaequalis,* and *Cytherideis subaequalis ulrichi.*

Florida Dept. Conservation, Geol. Bull. 13, p. 13, pl. 3, figs. 27–30; pl. 4, fig. 8.

Dimensions.—Length, 0.90 mm.; height, 0.38 mm.

Distribution.—Rare, Yorktownian; figured specimen from sample VA-12.

CYTHERIDEIS RUGIPUSTULOSA Edwards
Plate 78, figures 20, 22, 23

Cytherideis rugipustulosa EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 514, pl. 86, figs. 5–7; SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 20.

Dimensions.—Length, 0.90 mm.; height, 0.39 mm.

Distribution.—Yorktownian; figured specimens from samples VA-9, VA-12.

Remarks.—The Yorktown specimens are larger than those from the Duplin marl.

Taxodont hinge group
Genus EOCYTHEROPTERON Alexander, 1933
EOCYTHEROPTERON YORKTOWNENSIS Malkin, n. sp.
Plate 79, figures 1–4

Description.—Carapace minute, thick-shelled; dorsal margin straight in left valve, very slightly arcuate in right valve; anterior broadly rounded; posterior with blunt, rounded weak caudal process at about mid-height; ventral outline straight, converging towards posterior; ventral margin sinuous. Greatest height just anterior of center; greatest convexity near ventral margin with swelling that rises abruptly and overhangs margin in a pouch-like structure, which in some specimens shows an incipient ventral keel at the height of the convexity. Hinge line equals about three-fifths the length of valve. Surface shows numerous normal pore canal openings, and is covered by fine tessellation on which is superposed a faint horizontal lineation.

Interior of valves deep; in mature specimens inner lamella thin, marginal area broad anteriorly and posteriorly, relatively narrow ventrally; in young molts marginal area very narrow. Radial pore canals few, short; line of concrescence close to outer margin at anterior and posterior ends, converges with inner margin ventrally. Hinge simple taxodont; a long gently curved denticulate bar below dorsal margin of left valve fits into a denticulate groove in right valve. Above ends of bar are very short shallow sockets, slits in the cardinal areas, into which fit thin projections of the dorsal margin of right valve. Right valve has very fine raised thread-like lip around outer edge of marginal area that fits into a thin faint lip-line in marginal area of left valve.

Diagnosis.—The shape, ornamentation, and hinge of this form distinguish it from the several species of *Loxoconcha* in this fauna, which it resembles superficially.

Dimensions.—Length, 0.39 to 0.46 mm.; height, 0.20 to 0.26 mm.

Distribution.—Yorktownian; cotypes from samples VA-4, VA-12.

Genus PARACYTHERIDEA Müller, 1894
PARACYTHERIDEA VANDENBOLDI Puri, 1953
Plate 79, figure 5

Cytheropteron nodosum ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 129, pl. 38, figs. 37–40. Not *Cytheropteron nodosum* Brady, 1868.

Paracytheridea nodosa HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 37, pl. 3, fig. 7; SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 51, pl. 3, figs. 19–22.

Paracytheridea vandenboldi PURI, 1953, Jour. Paleontology, vol. 27, p. 751.

Distribution.—Figured specimen from sample VA-12.

PARACYTHERIDEA SHATTUCKI (Ulrich and Bassler)
Plate 79, figures 6–9

Cythere (?) shattucki ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 121, pl. 38, fig. 10.

Description.—Carapace subtrapezoidal, thin-shelled, wedge-shaped in dorsal view with greatest thickness posterior; dorsal margin straight, short, about one-half the length of carapace; anterior broadly rounded; posterior straight, truncate in dorsal two-thirds, rounded near ventral edge, with the curve rounding gradually into ventral margin; ventral margin irregular, not convex except at anterior end where rounded into anterior margin. Greatest thickness of carapace near ventral edge, where valve is subalate; alation interrupted near posterior end by a faint curved sulcus extending toward center of valve, so that

outline of valve appears notched, and with slight extension post-central; behind the notch valve is lower and edge is sharply carinate. Greatest height at anterior cardinal angle. Surface of valve with numerous regularly spaced normal pore canals. Each pore canal opening is surrounded by very faint punctation or tesselation arranged in hexagonal pattern.

Interior of valve deep; marginal area relatively narrow except at anterior end; line of concrescence coincides with inner margin except at anterior end where anterior rounds into ventral margin; in that area the line of concrescence is midway between inner and outer margin. Radial pore canals few. Hingement weak, simple; left valve has dorsal edge very finely crenulate, with shallow slit-like terminal sockets under cardinal angles; in right valve a shallow minutely crenulate groove below the dorsal edge is terminated by small sharp tooth-like extensions of dorsal margin. Muscle scar pattern a crescent-shaped row of four elliptical scars below the center, with two irregular scars in front of the crescent.

Diagnosis.—The relation of *P. shattucki* to closely related forms *P. shattucki curta* and *P. similis* is shown in figure 11. *P. shattucki* is distinguished by its greater number of normal pore canals, smooth surface, smaller size, weaker hingement.

The ventral notch is much more prominent in some specimens than in others; this feature is probably related to sexual dimorphism.

Dimensions.—Length, 0.49 to 0.53 mm.; height, 0.28 to 0.30 mm.

Distribution.—Rare, Choptankian and Kirkwood; figured specimens from samples NJ-9 and MD-14-5.

PARACYTHERIDEA SHATTUCKI CURTA, Malkin, n. subsp.
Plate 79, figures 10–12

Paracytheridea ? wetherelli (Jones) SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234–A, p. 51, pl. 7, figs. 2–4.

Description.—Similar to *P. shattucki* but larger and slightly longer in proportion to height; posterior end obliquely truncate; dorsal margin straight, short, less than half the length of carapace; ventral margin straight, obscured in side view by overhang of angled convexity of valves. In some specimens a narrow elongate depression parallels the posterior fourth of the ventral edge. Surface minutely punctate and marked with irregularly spaced normal pore canals.

Interior deep, marginal area moderately broad, line of concrescence coinciding with inner margin except for a short distance in anteroventral area. Muscle scars arranged in a crescentic row of 6 to 7 elliptical scars below and anterior to center of valve. Hinge a minutely crenulate bar and two round shallow terminal sockets in left valve; a deep groove with denticulate lower edge below dorsal margin, and small rounded cuspate terminal teeth in right valve.

Diagnosis.—Figure 11 shows the distinction, on the basis of length of hinge, between the species and this subspecies. *P. shattucki curta* (so named because of the short hinge) forms an almost continuous series with *P. shattucki* when specimens of both are arranged according to decreasing proportional length of hinge. It is differentiated as a subspecies because of its larger size, few normal pore canals, and stronger hingement.

Immature individuals have weak archidont hinge, very narrow marginal area, thin shells.

Dimensions.—Length, 0.58 to 0.62 mm.; height, 0.29 to 0.32 mm.

Distribution.—Rare, Yorktownian; cotypes from samples VA-5, VA-10, VA-12.

PARACYTHERIDEA SIMILIS Malkin, n. sp.
Plate 79, figures 13, 14

Description.—Carapace subtrapezoidal in side view; almost rectangular. Dorsal margin straight, long, about two-thirds the length of valve; anterior broadly rounded, almost straight; posterior truncated, with blunt angulation below middle; ventral margin straight. Surface marked with irregularly spaced normal pore canals and covered with relatively coarse punctae; in some valves punctae are arranged in hexagonal pattern around pore canal openings as in *P. shattucki*. Height constant throughout; thickness greatest in ventral half, and greater posterior than anterior. Convexity of valve drops abruptly from surface to ventral margin, forming a sharp right-angle break in slope.

Interior deep, marginal area moderately

broad; line of concrescence coincides with inner margin except in anteroventral area. Muscle scar pattern and hinge structure similar in all respects to *P. shattucki curta*.

Diagnosis.—This species is closely related to *P. shattucki* and *P. shattucki curta*, but has been classified separately because it does not appear to be continuous, in its variation limits, with either of those forms. It is distinguished by its punctae, long hinge line, stronger hingement.

Dimensions.—Length, 0.57 to 0.60 mm.; height, 0.26 to 0.28 mm.

Distribution.—Upper Yorktownian; cotypes from samples VA-2, VA-10.

Genus HAPLOCYTHERIDEA Stephenson, 1936

HAPLOCYTHERIDEA SUBOVATA (Ulrich and Bassler)

Plate 79, figures 15, 17

Cytheridea subovata ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 124, pl. 37, figs. 1–8.

Cytheridea (*Haplocytheridea*) *subovata* STEPHENSON, 1938, Jour. Paleontology, vol. 12, p. 134, pl. 23, fig. 23; pl. 24, figs. 9, 10; text figure 3.

cf. *Cytheridea* (*Leptocytheridea*) *waltonensis* STEPHENSON, 1938, Jour. Paleontology, vol. 12, p. 140, pl. 23, fig. 13; text figure 15. (Possibly young molt of *H. subovata*.)

Description.—Carapace large, thick-shelled, ovate in side view; dorsal margin arcuate with greatest height approximately at midlength; ventral margin slightly convex; ends rounded, or posterior bluntly acuminate in some specimens (male dimorphs ?). Valves evenly convex, slight swelling in posterior half. Surface smooth or sparsely pitted; widely scattered normal pore canals.

Interior of valves moderately deep; moderately broad marginal area, broader anterior; line of concrescence about midway between inner and outer margins; radial pore canals numerous, closely spaced. Hinge strong taxodont; in right valve TBT, in left valve SGS (Schmidt, 1948); teeth, sockets, bar, and groove distinctly denticulate. A raised lip near the free margins of right valve, continuous with the teeth, fits into a sunken lip-groove near free margin of left valve. Muscle scar anterior of center; an irregular vertical row of four circular scars and three or more irregularly spaced scars in front of the row.

Molts similar to mature carapaces in outline, differing in weak hinge structure, narrow marginal area, thinner shell. A series of several instars can be recognized. Young forms pictured as *C.* (*Leptocytheridea*) *waltonensis* Stephenson, 1938, are similar in outline; the specimens have not been compared.

Dimensions.—Length, 0.78 to 0.93 mm.; height, 0.47 to 0.50 mm.

Distribution.—Calvertian; common in Choptankian; figured specimens from samples MD-14-1, MD-14-6.

Genus CLITHROCYTHERIDEA Stephenson, 1936

CLITHROCYTHERIDEA DIAGONALIS Malkin, n. sp.

Plate 79, figures 18, 19, 21, 22, 24

Description.—Carapace elongate, reniform in side view; dorsal margin arcuate to subtruncate with bluntly rounded angulation anterior of middle at about two-fifths the length from anterior end, at position of greatest height; ventral margin sinuous, with concavity in posterior third; anterior rounded, ornamented with six or more delicate spines; posterior gently rounded, almost straight, passing into dorsal margin at rounded cardinal angle; posterior-ventral end nasute, more markedly in right valve; posterior may have a few spines. Greatest length of carapace at or near ventral edge, along a diagonal line from greatest extension of anterior to greatest extension of posterior. Convexity of valves regular, shell rising abruptly from all margins to meet the very gently convex surface at almost right angles. Except in very young molts, the change in slope at anterior end is marked by two rounded keel-like plications, paralleling anterior margin; similar plications parallel posterior margin. Surface heavily pitted, except in youngest molts, and with irregular reticulation superposed on the pitting.

From the interior, valves moderately deep. Muscle scar pattern a vertical row of four circular scars, with other irregular scars producing a roughly circular pattern.

Form A: Young molt; shell very thin, surface smooth except for normal pore canals; very narrow marginal area; hinge weak, simple taxodont or cryptodont: faintly den-

ticulate cusps and groove in right valve, sockets in bar in left. Lacks anterior and posterior plications.

Form B: Similar to Form A, but shell slightly larger, thicker; punctate; faint marginal ridges anterior and posterior.

Form C: Thick shell, heavily pitted; marginal ridges well developed. Marginal area very narrow; free margins thickly flanged so that sharp edge of right valve flange fits into thin lip-line in left valve flange. Hinge weak and poorly differentiated, as in younger molts. Externally this molt stage is indistinguishable from the mature forms; its immature marginal and hinge structure, however, identify it as a young stage.

Form D: Mature carapace; externally like Form C. Hinge moderately strong, well developed; in right valve elongate thin denticulate cusps at each end of a shallow denticulate groove (TGT); the inner wall of the groove is a continuation of the cusps; in left valve elongate elliptical denticulate sockets connected by a denticulate ridge (SBS); inner wall of the sockets is continuous with the ridge. Marginal area moderately wide, with numerous radial pore canals; line of concrescence coincident with inner margin except anterior where it is just outside of inner margin; flange and lip as in Form C; ventral flange concave centrally.

Diagnosis.—Differs from *Haplocytheridea proboscidiale* Edwards in hingement, and in having sharp change in slope of valves near margins. Differs also from *C. virginiensis* in shape, having its greatest length measured diagonally near ventral edge, whereas *C. virginiensis* is longest slightly below midheight, on a line parallel with ventral margin (figure 13). *Leptocytheridea chipolensis* Stephenson is similar in shape; it represents only young forms.

Dimensions.—Adult forms: length, 0.93 to 1.01 mm.; height, 0.51 to 0.55 mm.

Distribution.—Calvertian and Choptankian; cotypes from samples MD-13-3, MD-13-8, MD-14-1.

CLITHROCYTHERIDEA VIRGINIENSIS Malkin, n. sp.

Plate 79, figures 23, 25–28

? *Haplocytheridea* sp. aff. *H. israelskyi* SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 20, pl. 1, figs. 15–17.

Description.—Carapace ovate; shell thick, translucent; dorsal margin arcuate with blunt, rounded cardinal angulation just anterior to midheight; anterior broadly rounded; posterior rounded, oblique, passing into dorsal margin with a very gradual decrease in slope in right valve; change in slope of posterior margin more abrupt in left valve. In right valve, posterior margin meets ventral at a right angle; in left valve posteroventral angle is more rounded. Greatest extension of posterior is above ventral edge; greatest length of carapace about one-third the distance from ventral edge, measured parallel with ventral margin; ventral margin straight. Greatest height through anterior cardinal angle; greatest convexity central or just posterior of center. Convexity of valves rises more gradually from margins than in *C. diagonalis*. Six or more small but prominent marginal spines on anterior margin. Surface densely pitted; many of the pits in central part of valve in pairs; spaces between the pits form an irregular reticulation. Anterior, ventral, and posterior edges of valve ornamented by three low, unprominent plications parallel with margins. Vertical median sulcus slightly above center of valves.

From the interior, valves deep; thick flanges around free margins, with central sinuosity in ventral flange. Lip-line in flange of left valve. Marginal area thick, not wide, with radial pore canals not closely spaced, tending to occur in pairs. Line of concrescence coincides with inner margin ventrally; in the posterior it is just outside inner margin, and farther removed from inner margin at anterior end. Hinge taxodont: in right valve a prominent anterior denticulate cusp, followed by a short shallow denticulate groove that merges gradually with a less prominent posterior denticulate cusp, which merges in turn with the posterior marginal flange (TGT); in left valve a deep anterior elliptical denticulate socket, a low denticulate ridge that is higher anteriorly, separated from dorsal margin by a thin depressed line, and a shallow posterior elliptical denticulate socket ($S_B{}^GS$). Muscle scar pattern not observed.

Several molt stages can be recognized but they are difficult to distinguish from young forms of *Anomocytheridea floridana*

unless they are from instars advanced enough to have the deep pitting characteristic of *C. virginiensis*. Young forms figured as *Leptocytheridea mariannensis* Stephenson are similar in shape.

Diagnosis.—Differs from *C. diagonalis* in location of greatest length of carapace, in possession of median sulcus, in slope of convexity of valves. Shell is much thicker than that of *C. diagonalis*. The relationship of the two species is shown in figure 13.

Dimensions.—Length, 0.80 to 0.89 mm.; height, 0.48 to 0.50 mm.

Distribution.—Yorktownian; cotypes from samples VA-2 and VA-10.

Genus ANOMOCYTHERIDEA Stephenson, 1938

ANOMOCYTHERIDEA FLORIDANA (Howe and Hough)

Plate 79, figures 29, 30

Cytheridea floridana HOWE and HOUGH, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 10, pl. 2, figs. 15, 16, 18; pl. 4, figs. 6, 10.
Anomocytheridea floridana STEPHENSON, 1938, Jour. Paleontology, vol. 12, p. 142, pl. 23, fig. 15; pl. 24, figs. 7, 8; text figures 2, 6, 19, 20; EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 510, pl. 85, fig. 16, 17.

Description.—Carapace ovate; dorsal margin arcuate, truncate with a blunt angulation just in front of center; ventral margin straight to slightly convex; anterior and posterior ends rounded with greatest extension above ventral margin. Cardinal angles rounded; greatest height anterior of center, one-third of distance from anterior margin. Convexity rises gradually from margins and is regular, but slightly increased posterior to middle.

Form A: Shell thin; finely punctate with widely spaced normal pore canals; interior moderately shallow, convexity regular. Free margins flanged; marginal area narrow with few widely spaced radial pore canals. Hinge simple, weak taxodont, consisting of finely denticulate cardinal slits and serrate dorsal margin in left valve; finely denticulate thin cardinal cusps and fine serrate dorsal groove in right valve. Muscle scar pattern a subcentral vertical row of four subelliptical scars with an additional scar anterodorsal to the top of the row.

Form B: Shell thick, irregularly punctate, similar to mature carapace, but with narrow marginal area and weak hinge.

Form C: Mature carapace; shell thick, translucent. Surface pitted, with pits shallower and more widely spaced than in *Clithrocytheridea virginiensis*. Normal pore canals numerous. Interior moderately deep; free margins with thick flange, centrally sinuous ventrally; flange of right valve fits into lipline on flange of left valve. Marginal area moderately broad with irregularly spaced numerous radial pore canals of variable lengths; line of concrescence coincides with inner margin except anterior where it is just outside of inner margin. Muscle scars as in Form A. Hinge well developed, modified taxodont: in right valve an elongate strongly denticulate anterior cardinal cusp, a denticulate pit, a subdorsal bar, becoming denticulate toward the posterior and rising to posterior cuspate tooth; in left valve an elongate narrow elliptical denticulate anterior cardinal socket, elongate oblique tooth-like projection, a short subdorsal groove, and an elongate shallow cuspate posterior socket.

Diagnosis.—Distinguished from *Haplocytheridea subovata*, which it resembles in shape, by complex hinge, marginal flange, thicker shell. *Leptocytheridea choctawhatcheensis* (Howe and Stephenson) is similar to molts.

Dimensions.—Mature specimens, length, 0.98 to 1.07 mm.; height, 0.43 to 0.50 mm.

Distribution.—Yorktownian; figured specimens from sample VA-7.

Crasidont hinge group
Genus CAMPYLOCYTHERE Edwards, 1944

Campylocythere EDWARDS, 1944, Jour. Paleontology, vol. 18, pp. 514–515.
Acuticythereis EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 519.

After examining Edwards' type specimens of the genotypes and other species included in both genera, the writer is of the opinion that their differences are of degree rather than of kind. They are therefore treated as synonymous.

CAMPYLOCYTHERE LAEVA Edwards

Plate 80, figures 1–3

Campylocythere laeva EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 515, pl. 86, figs. 8–14.

Description.—Carapace oblong; dorsal margin straight, about three-fourths the length of shell; ventral margin almost straight, slightly sinuous, parallel with dorsal; anterior in left valve broadly rounded in oblique curve with greatest extensions in ventral fourth; in right valve dorsal third of anterior curve is obliquely truncated; posterior rounded with blunt rounded angulation at midheight. Valves thin in young molt; thick, translucent in mature carapace; surface unornamented except for openings of numerous randomly distributed normal pore canals. Muscle scar pattern a central vertical row of four elliptical scars with two or more small circular scars in front of the top of the row. Cardinal angles not prominent.

Form A: Young molt; similar in all respects except hinge and marginal area, to mature carapace. Hinge weak, or archidont type; marginal area narrow, pore canals few. Valves deep, uniformly convex.

Form B: Mature carapace; larger, thick-shelled. Hinge of right valve a triangular anterior tooth in the cardinal angle, followed by a thin elongate socket that merges posteriorly with a narrow finely serrate groove; in the posterior cardinal angle a thin triangular tooth with greatest height posterior; complementary structures in left valve. Marginal area moderately broad; line of concrescence just outside of inner margin; radial pore canals numerous, irregularly spaced.

Dimensions.—Length, 0.75 to 0.83 mm.; height, 0.31 to 0.38 mm.

Distribution.—Yorktownian; figured specimens from samples VA-2, VA-3, VA-12.

CAMPYLOCYTHERE LAEVISSIMA (Edwards)
Plate 80, figures 4–6

Acuticythereis laevissima EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 519, pl. 87, figs. 4–11.

Description.—Form A: Young molts; similar in shape to adult carapace; shell material thinner. Hinge very simple, weak archidont, with thin terminal, very faintly crenulated blade-like teeth and faintly denticulate groove in right valve; slit-like faintly crenulate sockets under cardinal angle of left valve, and dorsal edge of left valve indistinctly crenulate. Marginal area very narrow; radial pore canals few; normal pore canals well distributed over surface; muscle scar pattern same as in mature form.

Form B: Thicker shell; moderately broad marginal area; radial and normal pore canals numerous. Hinge archidont.

Form C: Mature carapace; left valve subovate; right valve more quadrate, with truncate anterior cardinal angle and obtuse posterior cardinal angle. Surface smooth to finely punctate. Marginal area broad; line of concrescence coincides with inner margin except at anterior. Free margins bordered on exterior by narrow clear area through which radial pore canals are visible. Hinge structure fine but distinct crasidont, consisting of thin elongate tooth, socket, faintly denticulate groove and small tooth, in right valve; complementary structures in left valve. Muscle scar pattern, visible in most carapaces, a vertical row of four elliptical scars with two faintly visible ones anterior of the row.

Dimensions.—Mature specimens, length, 0.68 to 0.78 mm.; height, 0.29 to 0.37 mm.

Distribution.—Choptankian, Yorktownian; figured specimens from sample VA-10.

Genus LEGUMINOCYTHEREIS Howe, 1935
LEGUMINOCYTHEREIS WHITEI Swain
Plate 80, figures 7–12

Leguminocythereis whitei SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 43, pl. 3, figs. 14, 16–18; pl. 4, fig. 1.

Description.—Carapace subtrapezoidal in side view; dorsal margin straight; ventral margin almost straight, protruding slightly in posterior half, converging toward dorsal; anterior margin gently rounded; posterior straight with greatest extension at ventral end; end margins converge towards dorsal edge so that greatest length of carapace is close to ventral margin. Cardinal angles both prominent in left valve; posterior cardinal angle rounded in right valve. Free margins with narrow thickened border most prominent anteriorly and posteriorly; ends denticulate in ventral half on some specimens. Greatest height through anterior cardinal angle; greatest convexity in posteroventral region where the convexity of the valve rises abruptly towards the dorsal edge. Small rounded muscle area anterior of center is present in most valves, obscure in some. Entire surface except marginal

borders covered with heavy coarse reticulations that vary in size and pattern. In specimens from younger beds the reticulations tend to be obscured by rugose irregular dendritic plications generally vertical in trend.

Form A: Young molt; archidont hinge; thin shell, small reticulations; prominent muscle spot; very narrow marginal area. few radial pore canals.

Form B: Moderately thick shell; archidont hinge; narrow marginal area, few radial pore canals; surface reticulate; reticulations obscured by rugose plications in some specimens.

Form C: Mature carapace; thick shell; large, coarse, irregular reticulations; double marginal rim. Broad marginal area with line of concrescence close to outer margin and numerous thin, closely spaced radial pore canals. Hinge moderately well developed, crasidont, consisting in right valve of prominent triangular anterior tooth, narrow elongate socket, serrate groove, and rounded posterior tooth; in left valve, anterior socket, thin elongate low tooth, narrow serrate bar, and posterior socket (TSGT and STBS).

Dimensions.—Length, 0.61 to 0.70 mm.; height, 0.29 to 0.34 mm.

Distribution.—Choptankian, Yorktownian; figured specimens from samples VA-4, VA-9, VA-12.

Genus LOXOCONCHA Sars, 1865
LOXOCONCHA RETICULARIS Edwards
Plate 80, figures 13–17

Loxoconcha reticularis EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 521, pl. 88, figs. 26, 27.

Description.—Carapace elongate ovate; shell thin, translucent; dorsal margin straight, or in some specimens very gently arched; ventral margin arcuate with deep anterior sinuosity, and greatest convexity of arch about middle; anterior highly arcuate with greatest extension below middle; posterior margin bluntly angled at midheight. Anterior margin joins dorsal in unbroken curve; posterior dorsal angle more prominent, obtuse, tending to be rounded in some specimens. A clear flange surrounds free margins, extending at right angles to margin and forming a border around contacts of free margins. The flange is broadest posteriorly and not visible from the exterior of the valves in the ventral sinuosity. Surface of valves punctate or finely reticulate, in a linear pattern roughly parallel with margins; reticulations coarser in specimens from older beds (see fig. 12). Several very thin raised lines parallel ventral margin and die out around the ends. Numerous normal pore canals. Greatest convexity subcentral; some specimens with slight swelling in posterior half (female dimorphs ?).

Interior of valves deep. Marginal area broad, irregular, broadest anteriorly; line of concrescence at inner margin below anterior cardinal angle, rapidly passing towards outer margin at anterior convexity, meeting inner margin at ventral sinuosity, and close to outer margin at posterior end. Radial pore canals widely spaced, short. At inner edge of marginal flange a fine thread-like lip in right valve fits into a fine lip-line in left. Muscle scar pattern a clear area, with four closely adjacent elliptical scars in a diagonal row anterior of center. Hinge in right valve a narrow arched socket in anterior cardinal angle with a small knob-like tooth below it and projecting into interior of valve, a fine serrate groove below dorsal margin, and in the posterior cardinal angle a narrow triangular tooth with greatest height posterior and posterior end of tooth slightly enlarged; in left valve a narrow curved anterior tooth with small rounded subjacent depression, a fine serrate bar separated from dorsal margin by a narrow incision, and an elliptical socket, deeper posterior.

Young molts are similar but have finer reticulations, archidont hinge, narrow marginal area, and less prominent clear flange.

Diagnosis.—The individuals assigned to this species have many features in common with species of *Loxoconcha* found in the Gulf Coast Jackson Eocene (*L. jacksonensis, L. vernonensis, L. mornhinvegi*) and Oligocene (*L. woodwardensis*) but differ from each in some respect—arrangement of reticulations, outline, marginal area, size. They differ also from *L. reticularis*, as described by Edwards (1944), in that the most coarsely reticulate specimens are not so coarsely reticulate as Edwards' types. This is regarded as a

phenotypic variation, and the variants are not given taxonomic rank. The relations of the Maryland-Virginia forms to the Duplin forms are shown in figure 10.

In general the specimens in the younger beds are more finely punctate, larger, with slightly more ventral sinuosity. The variation in characteristics is so gradual, however, that the late and middle Miocene specimens form a series and a line of demarcation cannot be drawn between them (fig. 10).

Dimensions.—Length, 0.46 to 0.52 mm.; height, 0.25 to 0.27 mm.

Distribution.—Throughout section; figured specimens from samples MD-14-6, VA-2, VA-6, VA-7, VA-10.

LOXOCONCHA SUBRHOMBOIDEA Edwards

Loxoconcha subrhomboidea EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 527, pl. 88, figs. 28–32; SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 25, pl. 2, figs. 18, 19.

Specimens having the characteristics of *L. subrhomboidea* are found associated with *L. reticularis* in the upper Yorktown beds. The dental bar and groove are more faintly serrate than is shown in Edwards' figures. Both young and mature individuals are recognized. They differ from *L. reticularis* chiefly in their finely punctate non-reticulate surface.

Dimensions.—Length, 0.48 to 0.58 mm.; height, 0.27 to 0.33 mm.

Distribution.—Rare, Yorktownian.

Heterodont hinge group
Genus CYTHEROMORPHA Hirschmann, 1909

CYTHEROMORPHA WARNERI Howe and Spurgeon
Plate 80, figures 18, 19

Cytheromorpha warneri HOWE and SPURGEON, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 11, pl. 2, figs. 5, 8, 9; pl. 4, fig. 4; SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 49, pl. 7, figs. 18, 19 (*C.* cf. *C. warneri*).

The individuals in this collection are less coarsely reticulate than those figured by Howe and Spurgeon.

Dimensions.—Length, 0.52 mm.; height, 0.30 mm.

Distribution.—Rare, upper Calvertian through Yorktownian; figured specimens from samples VA-2, VA-4.

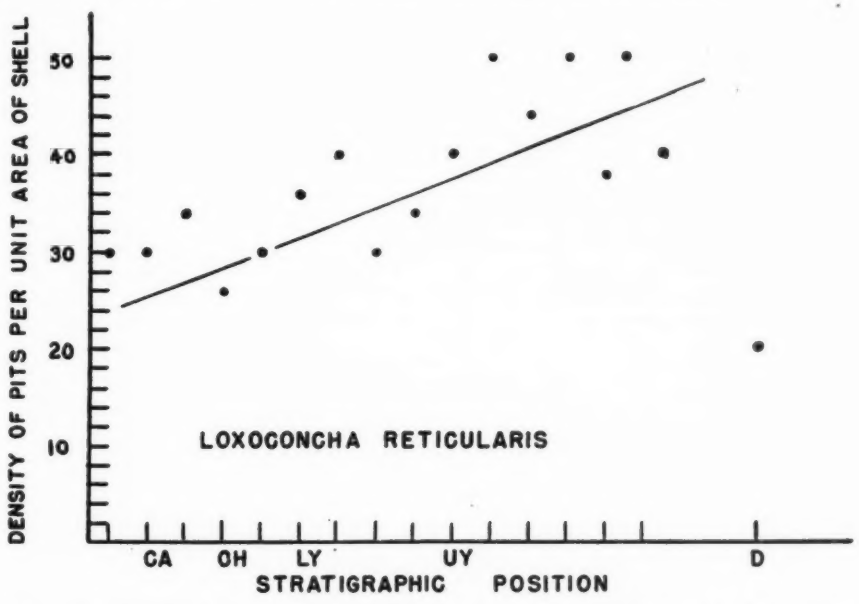


FIG. *10*—Variation in density of reticulations, *Loxoconcha reticularis*. Ca = Calvertian; Ch = Choptankian; LY = lower Yorktownian; UY = upper Yorktownian; D = Duplin.

Genus CYTHERURA Sars, 1865 (1866)
CYTHERURA CORYELLI Malkin, n. sp.
Plate 80, figures 20, 21, 25

Description.—Form A: Immature molt; carapace thin, small, pellucid, ovate; surface smooth, very finely perforate. Margins gently convex, except posterior, which has a subdorsal caudal acumination. Greatest height about one-half the distance from anterior end, at position of rounded cardinal angle. Convexity regular, greatest thickness approximately central. Interior of valves moderately deep. No inner lamella; thin marginal border. Hinge very weak, simple, archidont; tiny blade-like cardinal teeth and faint linear incision under dorsal edge of right valve; faint slit-like depressions in cardinal angles of left valve.

Form B: Mature carapace; small, reniform, thin-shelled, pellucid. Surface very finely punctate in faint fingerprint pattern. Dorsal margin gently convex, with slight concavity at position of anterior cardinal angle in right valve only; anterior end broadly rounded; posterior with short median caudal process, more produced in left valve. Hinge line in middle of dorsal outline, about one-half the length of the valves. Greatest height at rounded posterior cardinal angle, about one-fourth the length from posterior; greatest convexity in posterior half.

Valves moderately deep; edges flanged at right angles to margin with thin transparent flange that projects from valve surface along ventral contact. Slight overhang of posteroventral swelling beyond margin. Inner lamella broadest anteriorly, with widely spaced short radial pore canals; line of concrescence almost coincides with inner margin. Hinge in left valve a small triangular anterior socket, small cuspate tooth, thin sharp dorsal bar, and small posterior faintly serrate tooth (STBT); in right valve a small anterior tooth-like projection, rounded postjacent socket, groove below dorsal margin, and elongate posterior socket (TSGS). No muscle scar pattern observed.

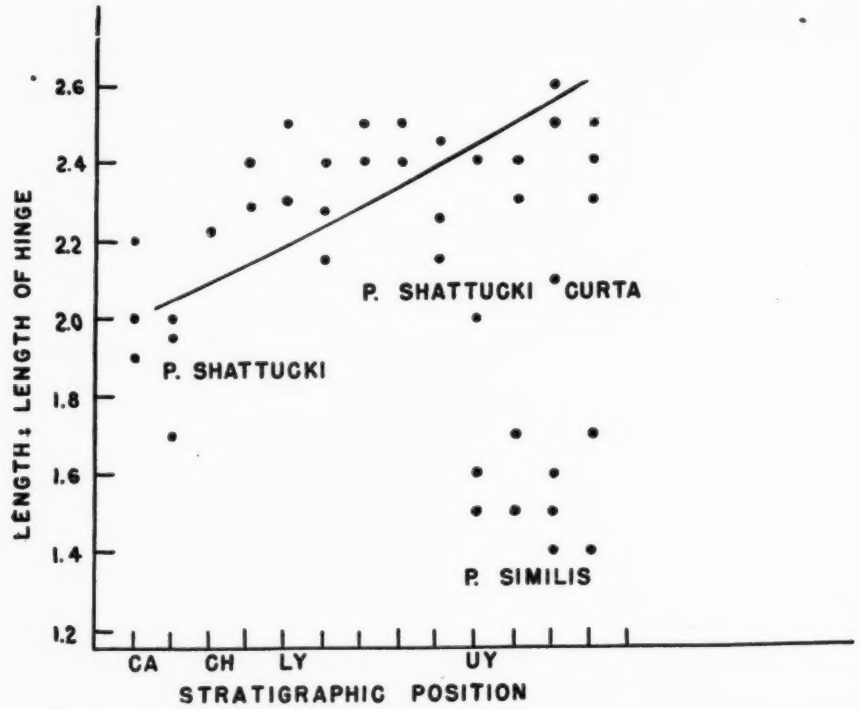


FIG. 11—Relation of *Paracytheridea shattucki*, *P. shattucki curta*, and *P. similis*. Ca = Calvertian; Ch = Choptankian; LY = lower Yorktownian; UY = upper Yorktownian.

A shorter variant, possibly a sexual dimorph, with straight ventral margin but similar in all other details is associated.

Diagnosis.—This species is distinct because of its ovate shape. Its hinge differs from other species in having cuspate teeth in the left valve, and in having an anterior tooth-like projection in the right valve. These features are not prominent, and do not appear to warrant generic distinction, because they are normal developments of a heterodont hinge of this type. *C. coryelli* resembles *Luvula palmerae* Coryell and Fields, from which it differs in outline and hinge detail.

Dimensions.—Length, 0.14 to 0.47 mm.; height, 0.23 to 0.27 mm.

Distribution.—Common to abundant in Choptankian; cotypes from samples MD-14-5, MD-14-6.

CYTHERURA FORULATA Edwards
Plate 80, figures 22–24

Cytherura forulata EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 526, pl. 88, figs. 17–20.

Individuals belonging to this species are shorter in proportion to height than those of *C. elongata* Edwards. In other respects they are similar and the two may be conspecific. The hinge of these specimens is similar to that of *C. coryelli*, but the teeth are not serrate.

Dimensions.—Length, 0.44 mm.; height, 0.19 mm.

Distribution.—Upper Yorktownian; figured specimens from sample VA-10, VA-12, VA-17.

Genus CYTHERETTA Müller, 1894
CYTHERETTA BURNSI (Ulrich and Bassler)
Plate 81, figures 7, 8, 10, 11

Cythere burnsi ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 103, pl. 36, figs. 34–39.

Cytheretta burnsi HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 33, pl. 2, figs. 12–14, 17; pl. 4, figs. 14, 21.

Cythere nitidula ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 107, pl. 36, figs. 21–28 (juv.).

Cythere nitidula var. *calvertensis* ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 108, pl. 36, figs. 24, 25 (juv.).

Cythere paucipunctata ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 105, pl. 38, figs. 7–9 (female ?).

Cythere burnsi as described by Ulrich and Bassler, and *Cytheretta burnsi* described by Howe, represent the mature forms of this species. Associated with mature specimens are molts representing several stages of development of the carapace. Such molts were described by Ulrich and Bassler as separate species, *C. nitidula* and *C. nitidula* var. *calvertensis*. *C. paucipunctata* appears to be an immature female carapace. The similarity in outline and presence of persistent features suggests the following ontogenetic series.

Description.—Form A: Carapace subovate; shape of valves similar to that of mature specimens. Shell thin, surface smooth. Marginal area very narrow (a thin rim around margin on interior of valves); few pore canals. Hinge simple, archidont; cardinal angles of right valve fit into shallow slits under cardinal angles of left valve; in left valve faintly crenulate bar, separated from dorsal margin by faint incised line, fits into thin shallow groove in right valve.

Form B: Shape and marginal area same as in Form A. Shell somewhat thicker; surface ornamented by short longitudinal rows of pits in posterior half of valve. Hinge of right valve has thin, weak, blade-like terminal teeth in incised cardinal angles; left valve similar to Form A.

Form C: Shape, surface ornamentation very similar to mature form. Marginal area slightly wider than in Form B; with fine thread-like lip near inner edge of right valve. Hinge primitive, archidont, as in Form B, but stronger.

Form D: Mature carapace; thick-shelled, elongate; dorsal and ventral margins nearly straight; anterior and posterior broadly rounded. Left valve much larger and higher than right, fitting over right valve along dorsal edge and at cardinal angles; right valve notched at cardinal angles where it fits under corners of the left. Surface with prominent, longitudinally arranged reticulations that die out near the margins.

Interior moderately deep. Hinge strong, well-developed heterodont; in the right valve a strong pointed tooth, deep socket, shallow groove, and curved posterior tooth (TSGT); in the left valve a prominent incurved projection at each end of dorsal margin, between which are the terminal

sockets, tooth, and thin bar that fit the corresponding structures in the right valve; accommodation groove in left valve above dorsal bar. Marginal area broad; radial pore canals long, numerous; line of concrescence coincides with inner margin. Raised lip around free margins of right valve fits into lip-line in left valve.

Dimensions.—Length, 1.09 to 1.15 mm.; height, 0.52 to 0.58 mm.

Distribution.—Common in upper Calvertian and Kirkwood; rare in Choptankian and Yorktownian; figured specimens from samples MD-14-6, VA-7.

CYTHERETTA PLEBIA (Ulrich and Bassler)
Plate 81, figures 1–6, 9

Cythere plebia ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 102, pl. 35, figs. 20–29.
Cythere plebia var. *capax* ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 103, pl. 35, figs. 30–33.
Cythere plebia var. *modica* ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 103, pl. 35, figs. 18–19.
Cythere porcella ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 106, pl. 36, figs. 26–33.
Cytheridea (?) chesapeakensis ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 125, pl. 37, fig. 9 (juv.).
Cytheretta plebia SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 212, pl. 14, figs. 3, 4.
?Cytheretta porcella SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 45, pl. 4, fig. 7.

Cythere plebia of Ulrich and Bassler represents the mature form of this species. Associated with mature shells are molts that are believed to represent several stages of development of the carapace. Molt stages were described by Ulrich and Bassler as *C. porcella*, and possibly also as *Cytheridea* (?) *chesapeakensis*, which is an archidont hinged form, but is not a young *Cytheridea*. *C. plebia* var. *capax* and *C. plebia* var. *modica* are individual variants and need not be given taxonomic status.

Description.—Form A: Young molt; shell small, thin, smooth; subovate with obliquely truncate cardinal angles; blunt, spinose posterior acumination; hinge adont or cryptodont; marginal area a very narrow interior border.

Form B: Shell thin, similar to Form A but larger and with faintly pitted surface; hinge weak, archidont, as described for *C. burnsi*, Form B.

Form C: Shell similar in size, shape, and ornamentation to Form D, but marginal area very narrow, pore canals few, hinge archidont, but stronger than in Form B.

Form D: Mature carapace; elongate subovate; shell thick. Right valve ovate; dorsal margin straight, long; ventral margin gently rounded to straight, with central sinuosity and slight projection in posterior half; anterior broadly rounded with greatest extension near ventral margin, and anterior cardinal angle very obtuse, not well defined; posterior bluntly angled at midheight, four or five spines bordering the acumination. Left elongate subovate; dorsal margin gently rounded, ventral margin straight, with sinuosity anterior of center; anterior margin with concave excision in cardinal region, remainder broadly rounded; posterior with deep concavity in dorsal half, ventral half bluntly acuminate at midheight, with tiny spines. Strong overlap of left valve over right at cardinal angles. Greatest thickness in posterior ventral quarter; height fairly uniform throughout. Surface irregularly marked with shallow pits, mostly in posterior half. Normal pore canals widely spaced over entire surface. Long radial pore canals visible in clear area bordering free margins.

Interior of valves moderately deep. Hinge strong, characteristic of the genus, as described for *C. burnsi;* accommodation groove above bar in left valve. Marginal area very wide, widest anteriorly, with characteristic S-shaped inner margin; long radial pore canals, numerous, with thickened ends. Line of concrescence close to inner margin. Right valve with raised lip around anterior margin; lip expands into broad flange inside ventral margin, that continues as a sharp lip inside posterior margin, and meets the posterior cardinal tooth.

Dimensions.—Length, 1.1 to 1.17 mm.; height, 0.54 to 0.59 mm.

Distribution.—Calvertian; figured specimens from samples MD-13-8; MD-14-1; NJ-9.

Genus TRACHYLEBERIS Brady, 1898, emend.
Sylvester-Bradley, 1948

TRACHYLEBERIS EXANTHEMATA (Ulrich and Bassler)
Plate 81, figures 16, 19, 20

Cythere exanthemata ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 117, pl. 36, figs. 1–5.
Cythereis exanthemata HOWE and HOUGH, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 18; SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 204, pl. 12, figs. 14, 15.
Trachyleberis exanthemata SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 37, pl. 6, fig. 5.

The surface features of this species were described by Ulrich and Bassler. The interior of the valves was described in detail by Howe and Hough in their description of *C. exanthemata* var. *marylandica* which differs only in proportions of the carapace. The *Trachyleberis*-type hinge is strong and well developed, consisting of pointed tooth-socket-groove-tooth in right valve; and socket-tooth-bar-socket in left valve. Dorsal margin of right valve fits under that of left.

Diagnosis.—*T. exanthemata* is closely related to *T. radiata*, as shown in figure 14. Forms intermediate between typical *T. exanthemata* and *T. radiata* resemble the former, but have features in common with both. More elongate than typical forms of *T. exanthemata*, and showing the posterior radial ventral sculpture and reticulation of *T. radiata*, the intermediate forms are classified with *T. exanthemata* because they appear to form part of a morphologic series with the typical forms.

Dimensions.—Length, 0.88 to 1.01 mm.; height, 0.44 to 0.51 mm.

Distribution.—Calvertian, Choptankian; common in upper Calvertian and Kirkwood; figured specimens from samples NJ-9, MD-13-6, MD-14-1.

Note: this species is the genotype of *Actinocythereis* Puri, 1953, and should be referred to that genus.

TRACHYLEBERIS RADIATA Malkin, n. sp.
Plate 81, figures 12–14

Description.—Carapace subrectangular, similar to *T. exanthemata* in side view. Dorsal margin straight; ventral margin almost straight, tending to converge with dorsal posteriorly; anterior and posterior margins broadly rounded in left valve; posterior bluntly angled above middle in right valve. Anterior and posterior ends flanged, edged with irregular small spines; high, angled anterior rim tends to break up into spines in ventral third in some specimens. Anterior and posterior flanges extend beyond dorsal margin at cardinal angles. Ridge parallels dorsal margin at dorsal edge, continues parallel to posterior edge, and meets a central, irregular diagonal ridge trending towards anteroventral area. Both ridges may tend to break into large spiny prominences similar to those in *T. exanthemata*. A large round precentral muscle area forms part of this central ridge. Three finer, sharp ridges radiate from the muscle area towards postventral area, and are in some specimens produced to spines at their termini; these ridges form part of a coarse reticulate pattern that covers the surface except the flanged marginal areas and a small prominent ocular area at anterior cardinal angle.

Interior of valves moderately deep; hinge strong, well developed, as in *T. exanthemata;* teeth angular. Moderately broad marginal area; line of concrescence near inner margin; ventral marginal area sinuous.

Diagnosis.—*T. radiata* is related to *T. exanthemata* as shown in figure 14, but is differentiated from it chiefly by its reticulate surface and postventral radial sculpture. It appears to be related to *T. martini* also, and to have developed from a common ancestor of that species, which is similar in shape and reticulation. The ancestral form could have been "*Archicythereis*" *retiplana* Schmidt, 1948 (which should probably be classified as *Trachyleberis retiplana*). *Cythereis martini* var. *punctopustula* Swain, 1948, should probably be referred to *Trachyleberis* as a subspecies of *T. radiata.*

Dimensions.—Length, 0.72 to 0.84 mm.; height, 0.41 to 0.47 mm. Cotypes, length, 0.73 mm., 0.82 mm.; height, 0.47 mm., 0.42 mm.

Distribution.—Calvertian, Kirkwood; cotypes from samples NJ-9, MD-13-3.

Note: Probably should be referred to *Actinocythereis* Puri, 1953.

TRACHYLEBERIS EXANTHEMATA GOMILLIONENSIS (Howe and Ellis)
Plate 81, figures 15, 17, 18

Cythereis exanthemata var. *gomillionensis* HOWE and ELLIS, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 19, pl. 1, figs. 6–12; pl. 4, fig. 3; EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 521, pl. 87, figs. 31, 32.

Description.—The forms in this group may constitute an allochronic subspecies, which differs from *T. exanthemata* and *T. exanthemata marylandica* in its somewhat smaller size and less coarse ornamentation. The surface spines are sharper and the spines in the central row are connected by an irregular sharp ridge, forming a divide between the dorsal and ventral halves. Fine irregular low sharp vertical ridges connect the central spines to the dorsal spines. An indistinct row of small granular nodes parallels the anterior margin between a row of marginal spines and a sharp inner marginal ridge. Hinge typical of *Trachyleberis*, strong, both anterior and posterior teeth of right valve pointed. Marginal area very broad and heavy with numerous radial pore canals throughout; line of concrescence near outer margin.

Trachyleberis mundorffi Swain (1951, p. 36) is very similar to this variety.

Dimensions.—Length, 0.80 to 0.88 mm.; height, 0.48 to 0.50 mm.

Distribution.—Yorktownian; figured specimens from samples VA-7, VA-8.

Note: Should be referred to *Actinocythereis* Puri, 1953.

TRACHYLEBERIS CLARKANA (Ulrich and Bassler)
Plate 82, figures 1–3

Cythere clarkana ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 98, pl. 35, figs. 1–10.
Cythere clarkana var. *minuscula* ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 99, pl. 35, figs. 11–14.
Leguminocythereis clarkana SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 207, pl. 14, fig. 6; 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 43, pl. 6, fig. 18.

Cythere clarkana var. *minuscula* of Ulrich and Bassler is a molt of *C. clarkana*, with archidont hinge and narrow marginal area. Mature carapace has well-developed heterodont *Trachyleberis* hinge, wide marginal area. It is well described by Ulrich and Bassler.

Dimensions.—Length, 0.91 mm.; height, 0.52 mm.

Distribution.—Calvertian, Kirkwood; figured specimens from samples MD-13-3, MD-13-8, MD-14-1.

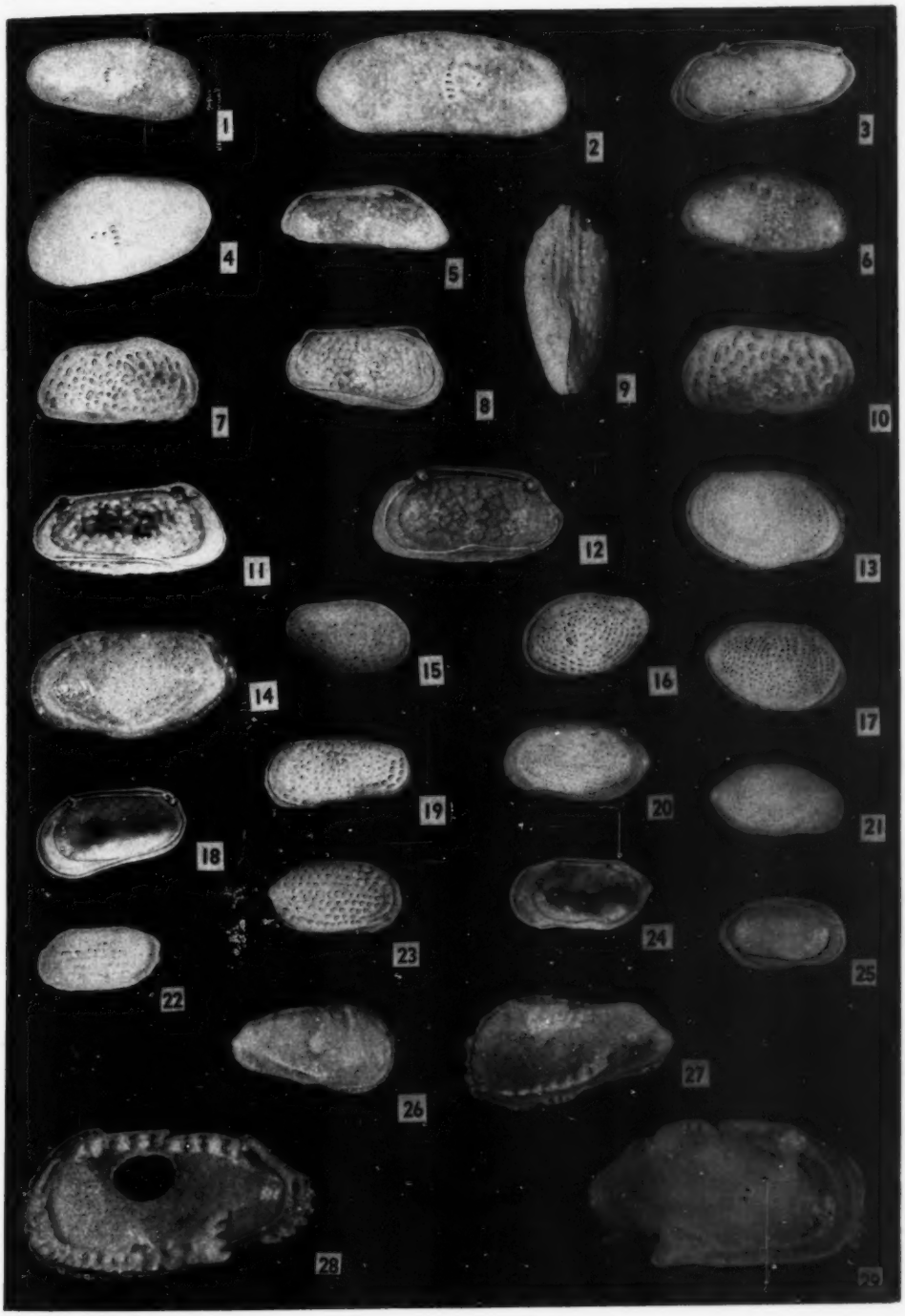
TRACHYLEBERIS EVAX (Ulrich and Bassler)
Plate 82, figures 4, 5

Cythere evax ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 119, pl. 36, figs. 6–8.
Cythere evax var. *oblongula* ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 119, pl. 36, figs. 9, 10.
Cythereis evax var. *oblongula* SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 204, pl. 12, figs. 19, 20.

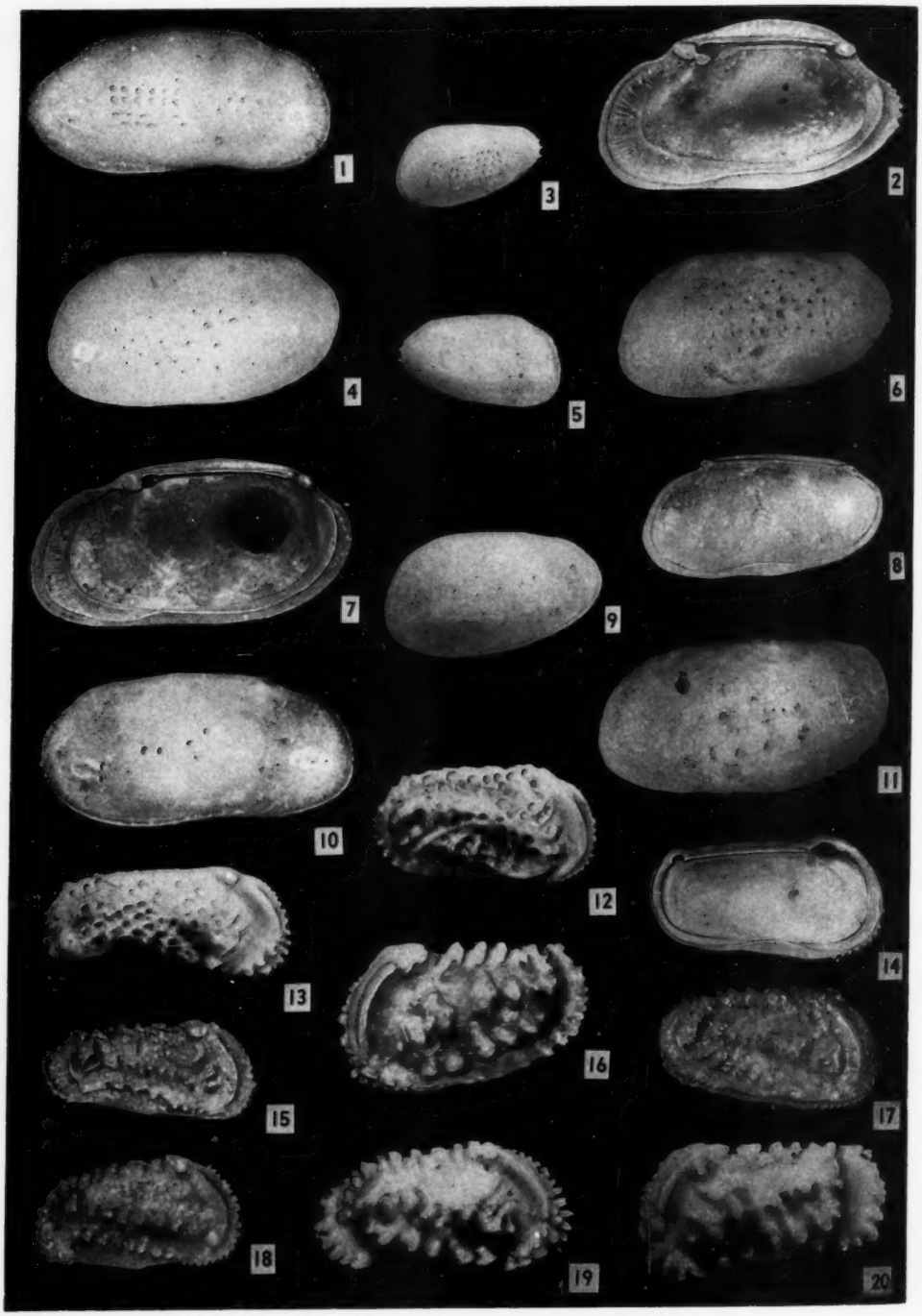
EXPLANATION OF PLATE 80

Magnifications approximately ×40.

FIGS. *1–3—Campylocythere laeva* Edwards. *1, 2*, right valves; *3*, right valve, interior. (p. 784)
4–6—Campylocythere laevissima (Edwards). *4*, left valve; *5*, left valve, interior; *6*, right valve. (p. 785)
7–12—Leguminocythereis whitei Swain. *7*, right valve; *8*, left valve, molt (Form B), interior; *9*, dorsal view; *10*, left valve; *11*, left valve, interior; *12*, right valve, interior. (p. 785)
13–17—Loxoconcha reticularis Edwards. *13, 15*, right valves; *14, 16*, left valves; *17*, right valve, molt. (p. 786)
18, 19—Cytheromorpha warneri Howe and Spurgeon. *18*, right valve, interior; *19*, left valve. (p. 787)
20, 21, 25—Cytherura coryelli Malkin, n. sp. *20*, left valve; *21*, right valve; *25*, left valve, interior. (p. 788)
22–24—Cytherura forulata Edwards. *22*, left valve; *23*, right valve; *24*, right valve, interior. (p. 789)
26–29—Pterygocythereis americana (Ulrich and Bassler). *26*, right valve, very young molt; *27*, left valve, molt; *28*, left valve; *29*, right valve. (p. 795)



Malkin, Miocene Ostracoda of New Jersey, Maryland, and Virginia



Malkin, Miocene Ostracoda of New Jersey, Maryland, and Virginia

Trachyleberis evax SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 28, pl. 3, figs. 1–3.

These specimens have the hinge of *Trachyleberis* and surface features described for *Cythere evax* and *C. evax* var. *oblongula*. The variety differs only in its greater length; the type specimens are the same in all other respects. Although insufficient individuals are available, it is believed that a continuous morphologic series connecting the two forms could be constructed.

Dimensions.—Length, 0.79 mm.; height, 0.51 mm.

Distribution.—Calvertian; Kirkwood; figured specimens from samples MD-14-1, MD-14-4.

TRACHYLEBERIS MARTINI (Ulrich and Bassler)
Plate 82, figures 6–13

Cythere martini ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 112, pl. 36, figs. 11–15.
Cythere producta ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 115, pl. 36, fig. 17; pl. 38, figs. 28–30.
Cythereis producta HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 22, pl. 1, figs. 31, 32, 35–37; pl. 4, figs. 11, 12.
Cythere micula ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 116, pl. 36, figs. 18–20 (juv.).
Cythereis martini SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 196, pl. 12, figs. 16, 17.
Trachyleberis ? martini SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 29, pl. 3, figs. 8, 15.

Description.—Form A: Young molt; carapace thin, subquadrate, small; surface finely reticulate, with raised central muscle area. Hinge line weak, archidont, consisting of small thin blade-like terminal teeth and a faintly denticulate groove in the dorsal area of right valve; shallow terminal sockets under the slightly produced cardinal angles of left valve; dorsal edge of left valve sharp, faintly serrate. Marginal area a very narrow border around free margins, with widely spaced radial pore canals. Specimens assigned to *Cythere micula* are molts of *T. martini*. In this stage, molts of *T. martini* and *T. radiata* may be indistinguishable.

Form B: Differs from Form A in having coarser reticulations, larger size, raised unreticulate marginal rims; archidont hinge and narrow marginal area similar to Form A.

Form C: Mature carapace; thick-shelled, reticulate; reticulations formed by the crossing of thin radial and concentric ridges. Free margins with thick, broad raised rim, which may be denticulate anteriorly and posteriorly. Slightly elevated rounded central muscle area; anterior ocular spot. Interior moderately deep. Hinge strong, *Trachyleberis*-type. Marginal area broad; radial pore canals long, numerous; line of concrescence coincides with inner margin except at anterior and posterior ends. (See description of *Cythereis producta* Howe, 1935.)

Diagnosis.—*Cythereis producta* is an elongate phenotypic variant, conforming in all other particulars with *T. martini* (fig. 12). The morphologic series *T. martini-C. producta* is not exactly continuous but the lack of continuity may be attributed to sampling.

T. martini is related to *T. radiata* but lacks the rugose ornamentation of that species.

Dimensions.—Length, 0.61 to 0.71 mm.; height, 0.28 to 0.34 mm.

Distribution.—Throughout section; common in upper Yorktownian; figured specimens from samples NJ-9, MD-13-7, MD-14-4, VA-2, VA-3, VA-7.

EXPLANATION OF PLATE 81

Magnification approximately ×40.

FIGS. *1–6, 9—Cytheretta plebia* (Ulrich and Bassler). *1*, right valve; *2*, right valve, interior; *3*, left valve, very young molt (Form A); *4*, left valve; *5*, right valve, molt (Form A); *6*, left valve, almost mature molt (Form C); *9*, left valve, molt (Form B). (p. 790)
7, 8, 10, 11—Cytheretta burnsi (Ulrich and Bassler). *7*, right valve, interior; *8*, right valve, interior, molt (Form C); *10*, right valve; *11*, left valve. (p. 789)
12–14—Trachyleberis radiata Malkin, n. sp. *12, 13*, right valves; *14*, left valve, interior. (p. 791)
15, 17, 18—Trachyleberis exanthemata gomillionensis (Howe and Ellis). Right valves. (p. 792)
16, 19, 20—Trachyleberis exanthemata (Ulrich and Bassler). *16, 20*, left valves; *19*, right valve. (p. 791)

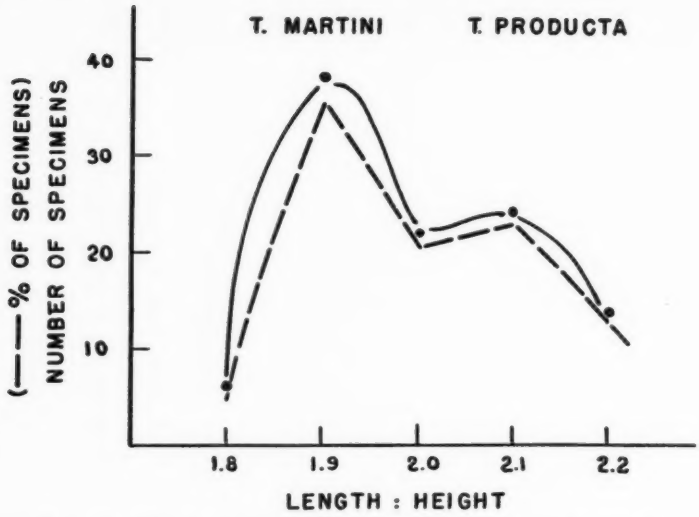


FIG. *12*—Distribution of length to height ratio in specimens of *Trachyleberis martini* and *T. producta*.

TRACHYLEBERIS VAUGHANI (Ulrich and Bassler)
Plate 82, figure 14

Cythere vaughani ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 109, pl. 38, figs. 25–27.
Cythereis vaughani HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 25, pl. 3, figs. 24–26; pl. 4, fig. 13. CORYELL and FIELDS, 1937, Am. Mus. Novitates 956, p. 9, fig. 10a. EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 522, pl. 87, figs. 27, 28.
Trachyleberis vaughani SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 37, pl. 6, figs. 6, 7.

Dimensions.—Length, 0.78 mm.; height, 0.40 mm.

Distribution.—Rare, Yorktownian; figured specimens from sample VA-7.

TRACHYLEBERIS DORSICORNIS (Ulrich and Bassler)

Cythere dorsicornis ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 113, pl. 36, fig. 16.
Cythere dorsicornis var. *bicornis* ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 114, pl. 38, figs. 32, 33.
Cytheridella chambersi HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 16, pl. 3, figs. 1, 2; pl. 4, figs. 16–20.
Archicythereis chambersi HOWE, 1936, Louisiana Dept. Conservation, Geol. Bull. 7, p. 57, 59.

Description.—Form A: Carapace subpyriform, thin-shelled, smooth to finely reticulate; small central swelling in muscle scar area. Hinge archidont; marginal area very narrow; pore canals few. (See description of *Cytheridella chambersi* Howe, 1935.)

Form B: Mature carapace; subpyriform in shape; dorsal margin straight; ventral margin almost straight, converging toward dorsal posteriorly; anterior rounded, bordered with thick raised denticulate round rim; posterior bluntly angled at midheight, has seven denticles below acumination. Surface evenly convex except for round raised pre-central muscle area and two pyramidal spine-like posterior protrusions at dorsal and ventral edge of top of posterior slope. Surface, except anterior rim and area bordering posterior end, is reticulate, with fine ridges and large inter-ridge depressions.

Interior moderately shallow; hinge *Trachyleberis*-type; not so strong as in most other species of the genus. Marginal area moderately broad; line of concrescence close to inner margin.

Diagnosis.—Ulrich and Bassler have listed the features that distinguish this species from *Cythereis producta* (*T. martini*). *Cythere dorsicornis* var. *bicornis* was founded upon a few valves in which the lower posterior spine is better developed than in most; both spines can be seen on all specimens. *Archicythereis chambersi*, a species based upon young individuals, has the shape and

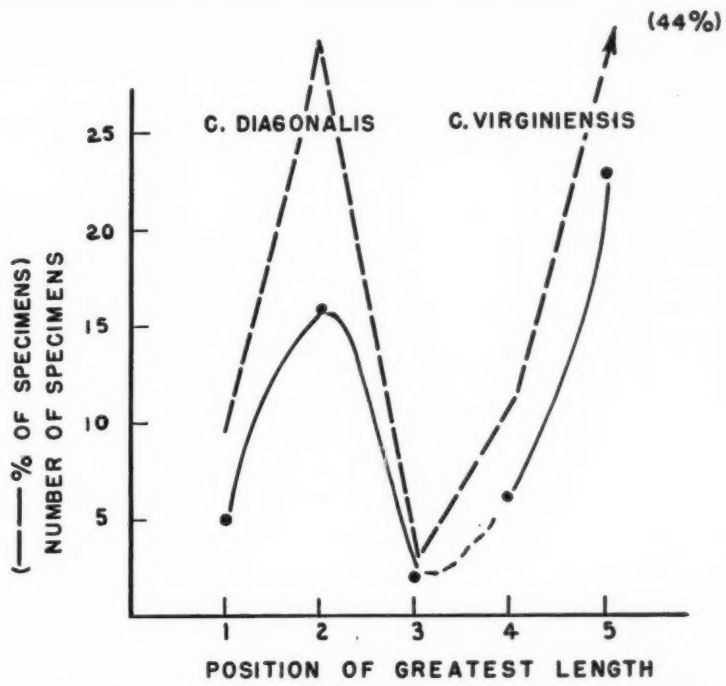


FIG. *13*—Position of greatest length in specimens of *Clithrocytheridea diagonalis* and *C. virginiensis*. 1, 2, 3, 4, 5 signify relation of greatest length of carapace to ventral margin, in a possible phylogenetic arrangement. 1=greatest length diagonal to ventral margin, posterior extension below margin; 2=greatest length diagonal to ventral margin, posterior extension at ventral margin; 3=greatest length diagonal to ventral margin, posterior extension one-fifth of height above ventral margin; 4=greatest length parallel to ventral margin, posterior extension two-fifths of height above ventral margin; 5=greatest length parallel to ventral margin, posterior extension about one-half of height above ventral margin.

surface characters of mature specimens of *T. dorsicornis;* molts have archidont hinge, narrow marginal area.

Dimensions.—Length, 0.60 mm.; height, 0.32 mm.

Distribution.—Calvertian.

Genus PTERYGOCYTHEREIS Blake, 1933

PTERYGOCYTHEREIS AMERICANA
(Ulrich and Bassler)
Plate 80, figures 26–29

Cythereis cornuta var. *americana* ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 122, pl. 37, figs. 29–33.

Cythereis (*Pterygocythereis*) *cornuta* var. *americana* HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 26, pl. 2, figs. 19, 21–24; pl. 4, fig. 24. SWAIN, 1948, Maryland Dept. Geol., Mines, Water Resources, Bull. 2, p. 206, pl. 13, fig. 4.

Pterygocythereis cornuta americana SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 41.

Because var. *americana* is distinctive in the en echelon arrangement of the parts of its dorsal crest, it is here given specific rank. Molts with archidont hinge are recognized.

Dimensions.—Length, 0.87 to 0.90 mm.; height, 0.46 to 0.48 mm.

Distribution.—Rare throughout section; figured specimens from samples MD-13–7, MD-13–8, VA-4.

Note: The genotype of *Pterygocythereis, P. jonesi* (Baird) (*Cythereis jonesi* Baird), was placed in his "group *Fimbria*" by Neviani (1928, p. 86). Neviani used the designation "group" as a subgeneric category, which would make subgenus *Pterygocythereis* Blake, 1933, a synonym. However, the name *Fimbria* was preoccupied for a mollusk by Bohadsch, 1761, and by Megerle, 1811, and for a tunicate by Risso, 1826. Therefore it appears that *Pterygocythereis* Blake stands. The genotype of *Fimbria* Neviani is *Cythere fimbriata* Münster.

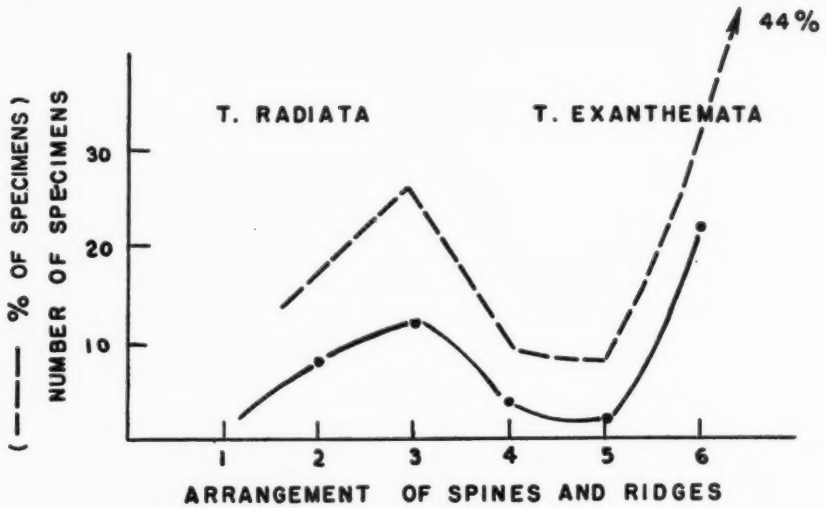


FIG. *14*—Relation of *Trachyleberis radiata* to *T. exanthemata*. 1, 2, 3, 4, 5, 6 signify types of arrangements of spines and ridges, in what appears to be their order of ontogenetic and phylogenetic development from type 1 to type 6. 1 = three subparallel ridges, no spines, no radiating postventral sculpture; 2 = three subparallel ridges, no spines, with radiating postventral sculpture; 3 = three subparallel ridges with prominent spines, with radiating postventral sculpture; 4 = three subparallel ridges with prominent spines, no radiating postventral sculpture; 5 = three subparallel rows of spines, with radiating postventral sculpture; 6 = three subparallel rows of spines, no radiating postventral sculpture.

Genus HEMICYTHERE Sars, 1925

HEMICYTHERE PUNCTISTRIATA
(Ulrich and Bassler)
Plate 82, figure 15

Cythere punctistriata ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 108, pl. 38, figs. 22–24.
Cythere francesca ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 110, pl. 38, figs. 19–21.

This species has a typical *Hemicythere* hinge. *Cythere francesca* appears to be a young molt.

Dimensions.—Length, 0.69 mm.; height, 0.33 mm.

Distribution.—Rare, Choptankian; figured specimen from sample MD-14–6.

HEMICYTHERE CONRADI Howe and McGuirt
Plate 82, figures 16–18

Hemicythere conradi HOWE and MCGUIRT, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 27, pl. 3, figs. 31–34; pl. 4, fig. 17. EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 518, pl. 86, figs. 17, 18. SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 42, pl. 6, figs. 9–12.

Description.—Form A: Young molt; shell thin; surface reticulate and pitted; reticulations small, coarse. Posterior caudal process prominent. Marginal area very narrow; radial pore canals widely spaced. Hinge simple, weak, archidont, consisting in right valve of sharp dorsal edge of valve with very faintly serrate groove below it and thin blade-like, very faintly serrate tooth at each end; in left valve dorsal margin is incurved to form a narrow shelf-like projection with a sharp faintly serrate edge that fits into the groove in the other valve; beneath each overhanging cardinal angle is an elongate socket to receive the teeth of the other valve.

Form B: Mature carapace; well developed strong hinge, typical of *Hemicythere*. Wide marginal area, numerous closely spaced radial pore canals. The form is described by Howe and McGuirt.

Dimensions.—Length, 0.49 to 0.55 mm.; height, 0.31 to 0.35 mm.

Distribution.—Yorktownian; common to abundant in upper part; figured specimens from samples VA-4, VA-10, VA-12.

HEMICYTHERE SCHMIDTAE Malkin, n. sp.
Plate 82, figures 19–23

Description.—Carapace elongate subovate; dorsal margin slightly arched; ventral

margin slightly sinuous, tending to converge with dorsal; anterior broadly rounded and curving into ventral margin, may be finely denticulate; posterior almost straight, oblique, with blunt short caudal extension, which may be denticulate, near ventral edge. Cardinal area extends above rest of dorsal margin. Greatest height through anterior cardinal angle; convexity similar throughout. Entire margin with a thickened, rounded clear border, broadest anterior and posterior; the thickened border rises from the margin to form a rounded rim on anterior and posterior ends. Surface, except rims and borders, covered with coarse, irregular, angular reticulations, arranged in a roughly radial pattern, and with normal pore canals in the large inter-reticular spaces. Eye spot in anterior cardinal area; large rounded muscle area anterior of center. Clear rounded ventral ridge extends between anterior and posterior rims parallel with ventral margin, at the edge of the convexity of valve, and terminates posteriorly in a low acumination. A similar ridge branches from dorsal border ridge, about one-third of the distance from posterior caudal acumination, ending in a blunt spine before reaching the rim.

Form A: Young molt; similar in all respects except hinge and marginal area, to adult form, but more fragile, thinner, more delicately ornamented. Hinge simple, weak, archidont, consisting of thin, rounded elliptical to blade-like very delicately cuspate terminal teeth and faintly denticulate groove in right valve; corresponding shallow sockets and faintly serrate ridge in left valve. Marginal area narrow, radial pore canals few, widely spaced.

Form B: Adult carapace; interior of valves moderately deep; marginal area wide; line of concrescence almost coincident with inner margin; radial pore canals numerous. A fine, thread-like lip near outer edge of marginal area of right valve fits into a fine lip-line near outer edge of left valve. Hinge strong; in the right valve a large knob-like elliptical two-cusped tooth in front of a small socket occupies anterior cardinal angle; long subdorsal groove, shallow posterior socket and elliptical tooth fit the complementary structures of the left valve. In left valve a large deep elliptical anterior socket with a narrow opening into interior; behind the socket a low elliptical tooth continuous with a thin finely crenulate ridge that ends in a low rounded prominence in front of an elliptical posterior socket in posterior cardinal angle.

Diagnosis.—This species is distinctive because of its shape and ornamentation. It is more rectangular and the reticulation is more radial than in *H. conradi*. It resembles *H. punctistriata* in outline, but differs in surface features. *H. schmidtae* may be identical with *Trachyleberis ?* cf. *T. ? reesidei* (Swain) (Swain, 1951, p. 30. pl. 3, fig. 13).

Dimensions.—Length, 0.63 to 0.69 mm.; height, 0.35 to 0.45 mm.

Distribution.—Yorktownian; common in lower part; cotypes from samples VA-4, VA-7, VA-9, VA-12.

Genus FAVELLA Coryell and Fields, 1937

FAVELLA RUGIPUNCTATA (Ulrich and Bassler)

Plate 82, figure 24

Cythere rugipunctata ULRICH and BASSLER, 1904, Maryland Geol. Survey, Miocene volume, p. 118, pl. 38, figs. 16, 17.

Cythereis rugipunctata HOWE, 1935, Florida Dept. Conservation, Geol. Bull. 13, p. 23, pl. 1, figs. 18, 20–22; pl. 4, figs. 22, 23.

Favella rugipunctata EDWARDS, 1944, Jour. Paleontology, vol. 18, p. 524, pl. 88, figs. 5, 6.

Trachyleberis ? rugipunctata SWAIN, 1951, U. S. Geol. Survey Prof. Paper 234-A, p. 38, pl. 6, fig. 8.

The name *Favella* is preoccupied by *Favella* Jörgensen, 1925, a tintinnid (Protozoa); the ostracod should be renamed.

Distribution.—Rare, upper Yorktownian; figured specimen from sample VA-12.

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RÉSUMÉ OF MICROFOSSILS FROM UPPER CRETACEOUS FLINTS AND CHALKS OF EUROPE

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ABSTRACT—Microscopic study of specially prepared samples of Upper Cretaceous flints and chalks reveals the presence of remains or traces of organisms from unicellular plants to vertebrates.

INTRODUCTION

Most of the flintstones which have been the subject of my research work are directly or indirectly of Upper Cretaceous (chiefly Senonian and Danian) origin. Opaque flintstone, which is frequently found in my country in boulders of the Baltic glaciation, proved to be comparatively rich in organic content and organic-chemical diagenetic remains of the original sediments. As a rule, splinters of these sediments, procured after the method of Walter Wetzel (1922, pp. 48–51), are rather transparent when immersed in alcohol or another liquid of higher refractive index in a watch glass viewed at medium magnification. Application of this process generally obviates toilsome and expensive preparation of transparent sections of flint splinters. This comparatively convenient method of microscopic investigation of flint splinters may be complemented by study of the organic-chemically preserved microfossils, after dissolution of the silica matrix in hydrofluoric acid of high concentration. Another method of microscopical research, which has been utilized, especially with Cretaceous chalks, is study of residues after treatment with hydrochloric acid.

Remains or traces of organisms from unicellular plants and animals to vertebrates are contained in the flintstone or its chalky matrix. In regard to the original composition of these remains, they may be classed as:

Calcareous skeletons.—It is necessary to recognize the possibility of decalcification and transformation after deposition, as observed with certain foraminifers, bryozoans, and echinoderms. Transformation of calcareous material affects chiefly the smaller particles and is often retarded when more compact portions of the skeleton are encountered. For this reason, in Foraminifera for example, all grades of transformation may be observed, up to complete metasomatosis. In many such cases, identification of species is impossible.

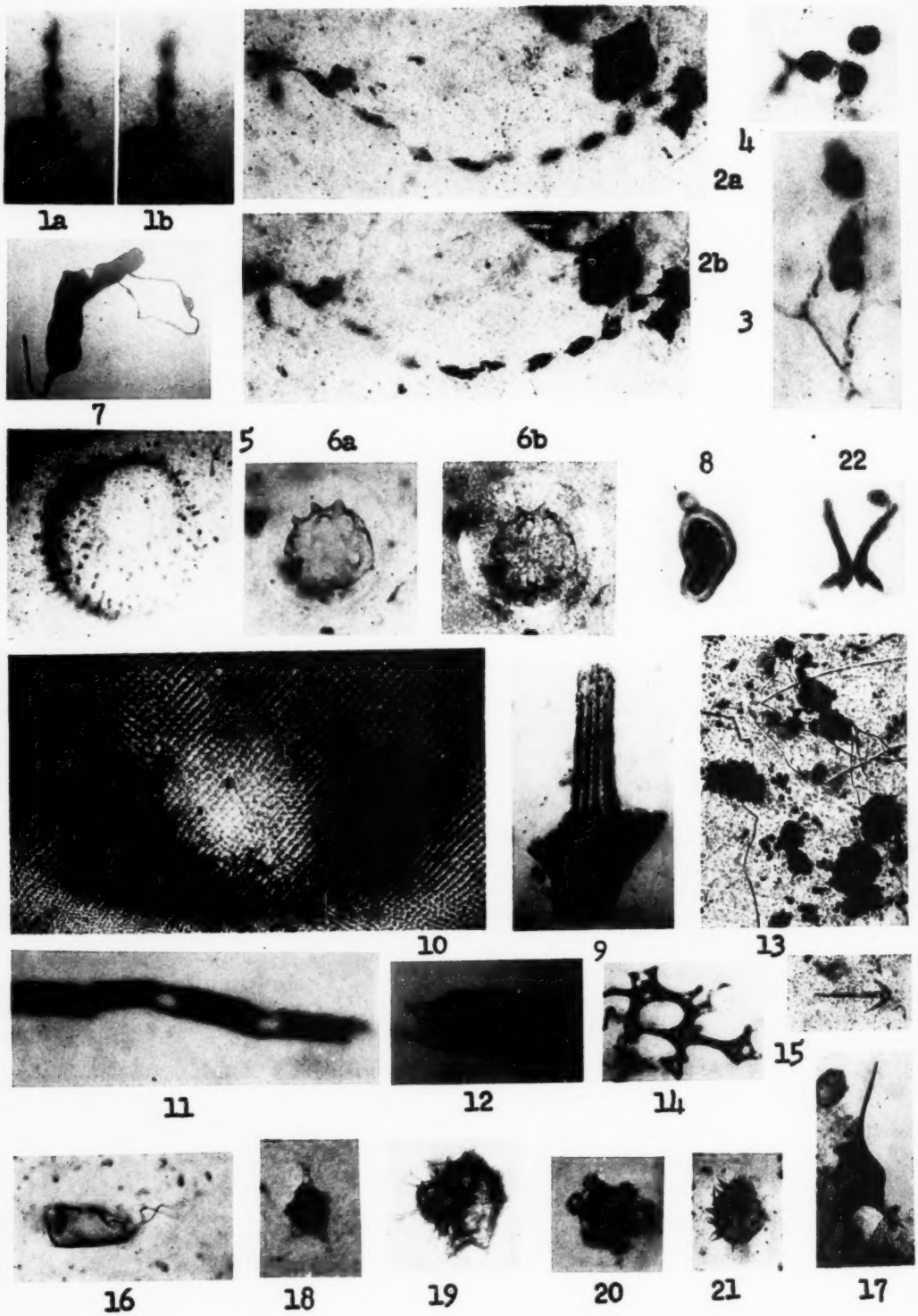
Siliceous shells and skeletons and their pseudomorphic transformations.—Siliceous colloids, while still liquid, may have been concentrated in the bottom of Cretaceous seas after dissolution of shells and skeletons of diatoms, radiolarians, and silicisponges.

EXPLANATION OF PLATE 82

Magnifications approximately ×40.

FIGS. *1–3—Trachyleberis clarkana* (Ulrich and Bassler). *1*, left valve; *2*, right valve, Interior; *3*, right valve. (p. 792)
4, 5—Trachyleberis evax (Ulrich and Bassler). *4*, right valve; *5*, left valve. (p. 792)
6–13—Trachyleberis martini (Ulrich and Bassler). *6*, right valve, interior, molt (Form A); *7*, left valve, interior, molt (Form A); *8*, right valve, molt (Form A); *9*, right valve, molt (Form B); *10*, left valve, adult; *11*, right valve, adult; *12*, left valve, interior, adult; *13*, left valve, interior, almost mature molt (Form B). (p. 793)
14—Trachyleberis vaughani (Ulrich and Bassler). Right valve. (p. 794)
15—Hemicythere punctistriata (Ulrich and Bassler). Right valve. (p. 796)
16–18—Hemicythere conradi Howe and McGuirt. *16*, right valve; *17*, *18*, left valves. (p. 796)
19–23—Hemicythere schmidtae Malkin, n. sp. *19*, right valve; *20*, left valve, interior, molt (Form A); *21*, left valve; *22*, right valve, interior; *23*, left valve, interior. (p. 796)
24—Favella rugipunctata (Ulrich and Bassler). Right valve. (p. 797)

Malkin, Miocene Ostracoda of New Jersey, Maryland, and Virginia



Wetzel, Upper Cretaceous microfossils from Europe

Remains capable of resisting total dissolution may be expected only among more compact forms. Under special conditions, preservation may have been abnormal.

Fossils of chiefly organic-chemical preservation.—In this group of microfossils, including protistans, flagellates, annelids (scolecodonts), and bones, teeth, and scales of fishes, the organic substances have been exceptionally well preserved. This applies to organisms producing cellulose, chitin, cutin, and tectin, as well as to those having osseous skeletons with admixed phosphatic material.

Description of Selected Forms

CALCAREOUS SKELETONS

Foraminifera.—In case of complete decomposition of calcareous skeletons, thin organic residua of brownish color often coat the cavities. Pyritization may result in still darker colors of the fossils. The ability of certain forms to resist destruction is shown by their occasional preservation in nonsilicified chalks (O. Wetzel, 1948, p. 319, pl. 33, figs. 3–10). Perhaps the chains of dark nodules illustrated in plate 83, figures 1 and 2, are internal coats, i.e., the fillings of

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EXPLANATION OF PLATE 83

FIGS. *1–2*—Supposed moulds of Foraminifera forming chains of chambers; perhaps residues of rheophacid species. *a, b,* Different illustrations according to the part of the chain. Erratic flints. *1,* ×60, Cat. No. A644; *2,* ×20, Cat. No. A 1873. (p. 801)

3–4—Supposed moulds of Foraminifera forming branched tubes, perhaps residues of a *Rhizammina* species; other Foraminifera residua attached to the exterior? *3,* ×60, Cat. No. A 1942; *4,* ×80, Cat. No. A 1720. (p. 802)

5—Chamber of Foraminifera species indet. with pyrite filling the pores of the chamber. Erratic flint; ×35, Cat. No. A 1886. (p. 802)

6—Residue of another Foraminifera chamber. *a,* Chalcedon knob partly filling the cavern. *b,* The calcareous wall clearly seen by polarized light. Erratic flint; ×75, Cat. No. A 1839. (p. 802)

7—*Chitinodendron* cf. *C. longicarpus* Eisenack, 1937, a string-carrying blastula; perhaps related to Foraminifera. Residue from Senonian chalk of the Nusse (Holstein) deep boring; ×30, Cat. No. N 155. (p. 802)

8—"Brown corpuscle," occasionally contained in Bryozoa caverns, here perhaps in germing state. Erratic flint; ×65, Cat. No. A 1969. (p. 802)

9—Longitudinal view of a spine of a sea-urchin (fragment). Erratic flint; ×30, Cat. No. A 1650. (p. 802)

10—Girder structure without distinct contours; impressed negative from the shell of a sea-urchin? Erratic flint; ×40, Cat. No. 1796. (p. 802)

11—Chain of "horned" cells of the diatom *Trinacria,* i.e., pyritified or carbonized moulds of the cells. Erratic flint; ×320, Cat. No. A 1838. (p. 802)

12—Supposed mould (pyritized?) of a single cell of the diatom *Hemiaulus* sp. Residue of Upper Cretaceous chalk (Höver/Ndsa.) in hydrochloric acid; ×110, Cat. No. We.-Ha. 12. (p. 802)

13—Pyritized Radiolaria skeletons (fragments, spec. indet.); between it fragments of striped fish scales. Erratic flint; ×135, Cat. No. A 299. (p. 802)

14—Fragment of a pyritized Silicispongia skeleton, i.e., "lychniscs" of a Lychnicosa species. Erratic flint; ×15, Cat. No. A 1819. (p. 802)

15—Microscleral (pyritzied) of a Silicispongia, i.e., an "anatriaen" of a tetractinellid species. Erratic flint; ×30, Cat. No. A 446 (=D 47). (p. 802)

16—*Ophiobolus utinensis* O. Wetzel, 1932, a tiny tegument with a flagella. Erratic flint; ×450, Cat. No. A 241. (p. 803)

17—(*Palaeo-*) *Peridinium* cf. *P. tricuspis* O. Wetzel 1932. Residue from the Senonian chalk of the deep boring Nusse (Holstein) in hydrochloric acid. ×110, Cat. No. N 158. (p. 803)

18—(*Palaeo-*) *Peridinium* cf. *P. murrayi* (=*Per. oceanicum* nach SCHILLER, Dinoflagellatae, II, 1937, p. 259, figs. 256 a–b.) Erratic flint; ×115, Cat. No. A 1965. (p. 803)

19—*Hystrichosphaera furcata* Ehrenberg. Under it probably (*Palaeo-*) *Peridinium pyrophorum* Ehrenberg. Erratic flint; ×240, Cat. No. A 246. (p. 803)

20—*Cannosphaeropsis* cf. *C. aemulum* Deflandre. Erratic flint; ×120, Cat. No. A 1738. (p. 803)

21—Spined shell, i.e., a brown tegument with two kinds of spines, somewhat similar to a *Hystrichosphaera hirsuta* forma *varians* O. Wetzel, 1933. Erratic flint; ×50, Cat. No. A 1945. (p. 803)

22—Scolecodont of pincerlike form, perhaps from a *Cirrobranchia* sp. Erratic flint; ×170, Cat. No. 1838. (p. 803)

Note: Magnification indices should be taken as only approximate figures.
The catalogue numbers (Cat. No.) refer to the collection of micropreparations of the author.

chambers of rheophacid Foraminifera, and branched strings shown in plate 83, figures 3 and 4, may be residua of *Rhizammina* specimens.

Sometimes the outlines of chambers of Foraminifera are indicated by microscopic crystals of pyrite which formed in the pores of originally calcareous shells (pl. 83, fig. 5).

In a few special instances, the calcareous shells appear to have been altered by later silicification which partially filled the chambers (pl. 83, figs. 6a, 6b).

Finally, certain yellowish-brown strings, occasionally grading to black, connected to cysts of a like color, were formerly interpreted as horny Bryozoa or as hydrozoan polyps. Now they are considered *Chitinodendron* (Eisenack, 1938, pp. 236–238, figs. 9–20). Such cysts, on thin stalks, are found in chalk residua as well as in flints (pl. 83, fig. 7). A specimen of this particular nature is *Chitinodendron peruanum* O. Wetzel, 1939, found in a hydrofluoric acid residue of an exceptionally dark flintstone, of probable Upper Cretaceous age, from Peru.

Bryozoa.—Next to Foraminifera, Bryozoa are most common among flint microfossils with calcareous shells, especially in the latest Baltic Cretaceous (Danian). Various sections of bryozoan colonies often reveal a rather regular design (O. Wetzel, 1950, pp. 177–179, pl. 12, figs. 5, 9).

From a biological point of view, tiny spherical and principally organic objects within the bryozoan chambers, recently found in Holstein erratic flints, are exceptionally interesting (pl. 83, fig. 8). These objects are probably cysts, similar to "brown corpuscula" or statoblasts, rather than parasites of the bryozoans (O. Wetzel, 1950, p. 162, pl. 11, figs. 4–12; W. Wetzel, 1951, p. 34, figs. 1–7).

Echinodermata.—Tiny particles of calcareous shells and spines of echinoderms are occasionally found in flints (pl. 83, fig. 9). Transverse sections of spines of sea-urchins may be mistaken for radially symmetrical micro-organisms. The specimen illustrated in plate 83, figure 10, may be part of the shell of a sea-urchin.

A few sclerites of holothuroids have been found in splinters of flintstone. Their disc-like shapes may be confused with certain diatoms or radiolarians (O. Wetzel, 1953, pl. 1, figs. 20, 21).

SILICEOUS SKELETONS

Diatomaceae.—A flintstone erratic has yielded a supposed diatom consisting of a chain of about 12 cells, each 35 to 55 microns long. The cells appear to be rectangular and flat and originally may have been shaped like a triangular prism. At the edge of each corner is a large horn. The diatomologist Dr. F. Hustedt of Plön, Holstein, prefers to include this specimen in the genus *Trinacria*, instead of in the genus *Hemiaulus*. These genera are close relatives, and, unfortunately, diagnostic ornamentation of the cells could not be determined because the links of the chain are practically opaque, the specimen having undergone either pyritization at an early stage, or carbonization of the organic remains of the original algal colony (pl. 83, fig. 11; O. Wetzel, 1951, p. 103, pl. 13, fig. 1). Perhaps the fossil shown in plate 83, fig. 12, also belongs to this group of Diatomaceae, although its cell is much larger than those of the *Trinacria* described. It was found in Upper Cretaceous chalk.

In cavities of French flintstones of Turonian age, G. Deflandre (1941, pp. 878–880, figs. 1–7) observed a few siliceous transformations of diatom skeletons which have been described as *Thalassiosira cretacea*.

Radiolaria.—Siliceous fragments of Radiolaria are common in the lower marl and chalk beds of the Upper Cretaceous, but they are rare in Senonian and Danian deposits. Pyritized remains are referable to *Dictyomitra*, *Lithocampe*, *Theosyringium*, or related genera (O. Wetzel, 1932–1933, pp. 1–5, pl. 3, figs. 1–8). Several specimens of indeterminable radiolarian species are illustrated in plate 83, figure 13.

Silicispongia.—Transformation of skeletons of Silicispongia by secondary pyritization is also a striking geological feature, when they are fossilized in the flintstones. In most cases, only the fillings of cavities of microsclerae and other fragments are involved (pl. 83, figs. 14, 15). Radial or striated recrystallization of silica may be seen inside caverns formed by destruction of larger fragments (O. Wetzel, 1932, p. 134, pl. 3, figs. 2, 3).

FOSSILS OF CHIEFLY ORGANIC-CHEMICAL PRESERVATION

Protista.—The most remarkable remains

of this category are the tiny teguments, 20 to 40 microns long, still showing flagella in the fossil state, described by me (O. Wetzel, 1932–1933, pp. 176–184, pl. 2, figs. 30–34) from Baltic erratic flints and by G. Deflandre (1936a, pp. 10–13, pl. 1, figs. 1–8) from Cretaceous flint in France as *Ophiobolus*. One of these specimens is shown in plate 83, figure 16. As observed in living Protista, these organisms decay quickly after death, but the Cretaceous specimens, preserved in minute detail, give a clear impression of the plankton of which they were part even millions of years after being imbedded in "juvenile" siliceous solution. It is suggested that the flints enclosing the ophioboli formed relatively quickly while still inundated in marine chalky mud.

Fossil Peridinea are also typical representatives of Protista. It is regrettable that specifically distinct markings on the apparently cellulose shells of peridineans are generally not preserved in fossils. Otherwise it would probably be possible to identify, under favorable circumstances, a fossil peridinean species with a still living form, e.g. *Peridinium conicum* (Gran) Ostenfelt and Schmidt (G. Deflandre, 1937, p. 26, pl. 4, fig. 4), thereby proving the considerable geological range of such species. Forms different from those found in flints by Ehrenberg have been described (O. Wetzel, 1932–1933, pp. 160–167, pl. 2, figs. 1–25). The specimens shown in plate 83, figures 17 and 18, may also be species of Peridinea.

The so-called spined shells are even more common than Peridinea of typical outlines. They have existed from Paleozoic until today. Cretaceous representatives of this group, of which Ehrenberg (1836) had knowledge, have been repeatedly transferred from one systematic category to another. Because of the texture of the surface of the epidermis, most of these spined shells, especially those of the Cretaceous and Tertiary, have been placed in the family Hystrichosphaeridae O. Wetzel (1932–1933, pp. 77, 78). Eisenack (1938, pp. 10, 29) elevated the family to the status of "Group" Hystrichosphaeridea which he regarded as related to Peridinea. The specimen illustrated in plate 83, figure 19 belongs to this group, and has been identified as *Hystrichosphaera* cf. *H. furcata* Ehrenberg; however, it is possible that this specimen is adhering accidentally to the *Peridinium* species. Also I have recently observed the hystrichosphaerid of plate 83, figure 20, probably a *Cannosphaera* aff. *C. aemulum* Deflandre. The spined shell of plate 83, figure 21, a single and singular find in an erratic flintstone, is distinguished by the compactness, the brownish color of the tegument, and the two kinds of dark spines from the majority of simply spined hystrichosphaerids; in other respects it resembles *Hystrichosphaera hirsuta* Ehrenberg forma *varians* O. Wetzel.

Annelida.—Comb-shaped, bristly, and obviously organic (chitinous) fragments which might be identified with masticatory organs of annelids are found occasionally in flints and chalks. These "chaetacombs," as well as single and double chaetae of pincer-like form (pl. 83, fig. 22), have been classed as micro-conodonts (O. Wetzel, 1932–1933), in contrast to Paleozoic macroconodonts already known for a long time. Recently, Cretaceous micro-forms have been placed by American specialists as fossil scolecodonts. Their occurrence in the flints and chalks may be taken as proof of the existence of small annelids in Cretaceous seas (O. Wetzel, 1932–1933, pp. 81–89, pl. 6, figs. 17–35).

Pisces.—Amphicoelous vertebrae, sometimes with spines; the points of teeth, partly showing the fine structure of the pulpa; and fish scales, partly with thorns or stripes (pl. 83, fig. 13), have been found in flintstones and chalks, and reveal, even in their microscopic minuteness, the abundance of fish in Cretaceous seas.

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MESOZOIC AND LATE TERTIARY RADIOLARIA OF ROTTI

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ABSTRACT—Re-examination of the radiolarian fauna described by Tan Sin Hok from the island of Rotti, near Timor, and considered by him to be probably Pliocene, reveals the presence of saturnalids and other microfossils indicating a Mesozoic age. Another sample, collected by the First Netherlands Timor Expedition from a nearby locality, contains a radiolarian fauna which is probably Pliocene or Pleistocene in age. Twenty-five species and subspecies, six of which are new, are determined in this latter fauna, which is in some respect similar both to that of the adjacent seas of the present day and to various late Tertiary faunas previously described from Europe and North America.

INTRODUCTION

ALTHOUGH the Radiolaria are at present seldom used as time-indicators in stratigraphic work, it appears probable that in the future they will prove to be very useful for this purpose. It is well known that the group in general possesses two of the main characteristics necessary for good index fossils: being planktonic, they are ubiquitous in the oceans of the present day, and have apparently been so since the Paleozoic, and secondly, their siliceous skeletons are readily preserved in fine-grained marine sediments. Also, there is already a large amount of evidence in the literature to indicate that the radiolarian faunas of the major geological periods differed considerably from one another, thus providing the third necessary characteristic for a group of index fossils—short time-ranges. However, many more radiolarian assemblages must be described from sediments of various ages before it will be possible to use these fossils for accurate age determinations.

A survey of the literature on late Tertiary radiolarian faunas shows that the Miocene assemblages described from North American and European localities have certain characteristics in common, and are transitional between the early Tertiary and Recent faunas. But there is one East Indian assemblage, described as being late Tertiary in age, which does not fit into this general picture: it differs in many respects from other late Tertiary faunas, and is in fact similar to Mesozoic faunas described from many localities throughout the world. The author has re-examined sediments from this East Indian locality with the object of determining the reason for this apparent anomaly.

The fauna in question is that described by Tan Sin Hok (1927) from four samples of calcareous sediment collected near Bebalain, on the island of Rotti, near Timor. Three of these samples (Series 8, Nos. 149, 150 and 154) were collected by the First Netherlands Timor Expedition (1910–1912) under the leadership of Dr. G. A. F. Molengraaf, and the fourth (No. 384) was collected by Dr. R. D. M. Verbeek in 1898–99. Tan Sin Hok (1927, p. 9, footnote) considered this fauna to be "Young" Tertiary in age, probably Pliocene, and subsequent authors have in general followed this determination. However, Brouwer (1922, p. 74) had indicated that some of these samples (Nos. 149, 150 and 154) might be at least partly Mesozoic in age, and Tan Sin Hok's determination of a "Young Tertiary" age was never substantiated by convincing evidence.

The age of the fauna described from these four samples is of considerable importance, as it is the only radiolarian assemblage originally ascribed to the later Tertiary which has been described from the East Indian region. Through the courtesy of Dr. H. A. Brouwer, of the Geological Institute of the University of Amsterdam, and Prof. H. J. de Wijs, of the Instituut voor Mijnbouwkunde at Delft, the author has been able to examine some of the samples from

[1] Contribution from the Scripps Institution of Oceanography, new series, no. 654.

the First Netherlands Timor Expedition, which are stored at the latter institute.

The samples Nos. 149, 150 and 154 were examined, in order to see if any further indication of their age could be found. Nothing was observed to contradict the previous opinion of the present author (1952, p. 10) that this fauna is Mesozoic in age. In fact, this impression was strengthened by the finding of fragments of *Spongosaturnalis* and perhaps *Spongosaturninus*, typically Mesozoic forms which are not mentioned by Tan Sin Hok.

An examination was also made of the sample Series 8, No. 178, from near Bebalain, Rotti. Although Tan Sin Hok mentions this sample (1927, p. 17), he does not describe the Radiolaria contained. This fauna is described in some detail in the present paper, and it proves to be very late Tertiary in age, probably Pliocene or Pleistocene. In this sample, there are a few Mesozoic Radiolaria from the older formation mixed with the Tertiary forms; there can be no doubt that this is the result of reworking, and is not due to these species having persisted from the Mesozoic to the late Tertiary.

THE MESOZOIC SAMPLES

The author (1952) has previously stated, in general terms, the reasons for suspecting the samples Nos. 149, 150 and 154 (Series 8, First Netherlands Timor Expedition) to be Mesozoic in age. A re-examination of these three samples has established the presence in each of them, of saturnalids of the types figured in Plate 84, figures 1–5.

The specimens found are all fragmentary, and it is therefore not possible to make an accurate determination of the genera or species present. It is very probable, however, that some of the specimens belong to the genus *Spongosaturnalis* Campbell and Clark. This is the case with the form figured in Plate 84, figure 2, and perhaps also Plate 84, figure 3. The thorns on the proximal ends of the spines of these specimens are disposed in such a way as to indicate that the spherical shell was spongy, and not composed of simple lattice-spheres. Also, the ring of the specimen in Plate 84, figure 2, is apparently similar to that of *Spongosaturnalis spiniferus* Campbell and Clark—it is three-sided prismatic, and bears triangular, thorn-like spines. *Spongosaturnalis* has been found only in the Upper Cretaceous of California (Campbell and Clark, 1944b).

The specimen figured in Plate 84, figure 1, may belong to the genus *Spongosaturninus* Campbell and Clark, which also has been recorded only from the Upper Cretaceous of California. The thorns on the proximal end of the spine are arranged in seven transverse rows, and although this may indicate that a similar number of concentric spheres was present, it is not impossible that the sphere was partly or wholly composed of a spongy framework. The ring does not have the form of any of Campbell and Clark's species, *Spongosaturninus ellipticus*, *S. latuformis* and *S. parvulus*, but it has a striking similarity to the form described as *Saturnalis polymorphus* by Squinabol (1914, p. 293), this latter form having been found in the Jurassic of Cittiglio (Laveno), and the Cretaceous of Novale (Vicentino), Baone (Euganei), and Couldson (Surrey).

The fragments figured in Plate 84, figures 4 and 5, cannot be determined accurately, but they may be compared with the rings of *Saturnalis lateralis* (Upper Cretaceous of California, Campbell and Clark, 1944b), *S. dicranacanthos* (Italian Liassic, Jurassic and Cretaceous, Squinabol, 1914) and *S. variabilis* (Jurassic of Cittiglio, Squinabol, 1914).

Although these forms are not sufficient to give a closer indication of the age of the fauna, they are strong evidence for a Mesozoic age.

Associated with the chalky sample No. 150, is a piece of chert, which on sectioning shows, besides the Cyrtoidea present in the chalk, numerous bodies (text fig. 1) similar to those described by Davis (1950, p. 211) as *Meyenella meyeni*. Fossils of this type have been found in hard rocks from the Devonian to the Upper Cretaceous, and ac-

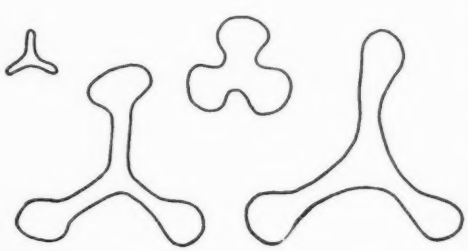


FIG. 1—"*Meyenella*"-like bodies observed in a thin-section of the chert sample No. 150. ×320.

cording to Davis they are most abundant in the Jurassic. At least in the present case, however, they are probably transverse and oblique sections of three-bladed prismatic spines, which occur in great numbers in the associated chalky sample. Tan Sin Hok (1927, p. 33) mentioned the abundance of such spines in the sediments which he examined, and assigned them to the Sphaeroidea.

THE LATE TERTIARY FAUNA

In pronounced contrast to the Mesozoic samples discussed above, most of the Radiolaria present in sample No. 178 are very similar to the forms at present living in the tropical oceans. That is, with the exception of some Mesozoic forms (such as *Stylosphaera squinaboli* Tan Sin Hok, *Tricolocapsa frequens* Tan Sin Hok, *Stichomitra pseudoscalaria* Tan Sin Hok, *Dictyophimus gracilis* Tan Sin Hok, etc.) which have obviously been reworked, and redeposited with the Tertiary forms as an heterochthonous element of the fauna. In the subsequent description of the fauna, these reworked forms will be ignored, but it is of interest to note their presence, as this is another example of the development of mixed micro-faunas, which are being recognized in an increasing number of instances.

The late Tertiary fauna of Rotti can be dated approximately by comparison with previously described Miocene and Pliocene faunas on the one hand, and the Recent fauna on the other. The absence or scarcity of any species closely corresponding to the widespread Miocene type represented by *Eucyrtidium delmontense* Campbell and Clark, and *Stichocorys saccoi* Vinassa, indicates that if the Rotti fauna is late Tertiary, it is probably post-upper Miocene. The presence and abundance of such forms as *Tetrapyle quadriloba* and *Larcospira quadrangula*, which are common in the tropical oceans of the present day, indicate an age not older than late Miocene. And the assemblage is distinguished from that of Recent tropical seas by the absence of such forms as *Euchitonia elegans*, *Panartus quadrijugus*, *Spongaster tetras*, and *Pterocanium tricolpum*, which, so far as our knowledge goes, are at present ubiquitous in the warm oceans (Riedel, 1952, pp. 11, 12). The stratigraphic significance of each of the forms present will be discussed in the systematic section below.

There is only one previous description of Pliocene Radiolaria, and this is the fauna described by Seguenza (1880) from the province of Reggio (Calabria). Unfortunately, Seguenza's species descriptions are often inadequate for identification of the forms, and there are no figures of the species which he found. Therefore, it is difficult to compare his fauna with that from Rotti, but nevertheless it is possible to trace some significant similarities between the two. For example, Seguenza's fauna includes two species of *Tetrapyle*, one of them *Tetrapyle* cf. *T. quadriloba* (Ehrenberg), which is the form occurring on Rotti; and one of the two species of *Pterocanium* which Seguenza describes from his material is apparently not very different from a species described in this paper.

The systematic description of the fauna from sample No. 178 (First Netherlands Timor Expedition), which follows, includes only the more common of the forms present. Species represented in the available material by only a few specimens are generally omitted, as it is usually necessary to have a considerable number to indicate the range of variation, and typical form of a species. The system of classification used is that of Haeckel (1887). The figures were drawn with the help of a camera lucida, and have been reduced during reproduction to one-third of their original size. Types and figured specimens will be stored in the collections of the U. S. National Museum, Washington, D.C.

SYSTEMATIC DESCRIPTION

Genus ACROSPHAERA Haeckel

? ACROSPHAERA INFLATA Haeckel

Plate 84, figure 10

Acrosphaera inflata HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 101, pl. 5, fig. 7.

There are a considerable number of specimens, mostly broken, which correspond with Haeckel's description except that the spines are longer (up to 60 μ). Because of this fact, and as it is impossible to determine whether these tests belonged to colonial Radiolaria, they are doubtfully assigned to this species. Haeckel described

the species from a surface sample from the North Atlantic.

? ACROSPHAERA sp.
Plate 84, figure 9

Shell thin-walled, spherical, with 15–25 short conical, often oblique spines arising from small, perforated, conical elevations of the shell surface. On the half equator are 8–15 subcircular pores of very varying diameter, 0.3–5 times as broad as the wide flat intervening bars.

Diameter of shell 75–110 μ; of the pores 4–22 μ. Length of the spines (including conical bases) 10–20 μ.

Tests of this species are rather common in the Rotti sediment, but, owing to their isolation, it is not possible to determine whether or not they belonged to a colonial radiolarian.

Genus SOLENOSPHAERA Haeckel
? SOLENOSPHAERA VARIABILIS Haeckel
Plate 84, figure 8

Tetrasolenia quadrata EHRENBERG, 1873, Abhandlungen der königlich Akademie der Wissenschaften zu Berlin, 1872, pl. 10, fig. 20.
Solenosphaera variabilis HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 113.

In the assemblage were found a few specimens of a form which corresponds to Ehrenberg's figure and Haeckel's description, except that the shells are generally smaller, and the porous tubuli are relatively longer and narrower.

The species has been recorded from the Indian Ocean between Zanzibar and the Comoro Islands, and from the central tropical Pacific.

Genus OTOSPHAERA Haeckel
OTOSPHAERA POLYMORPHA Haeckel

Otosphaera polymorpha HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 116, pl. 7, fig. 6.

Isolated shells correspond well with Haeckel's description, and it appears probable that they belong to this colonial species. The species was described from the surface of the Indian Ocean.

Genus HEXALONCHE Haeckel
HEXALONCHE PHAENAXONIA Haeckel

Hexalonche phaenaxonia HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 180.

The forms present in the sediment from Rotti correspond well with the original description. Haeckel recorded the species from the central Pacific, presumably in Recent sediments.

Genus SPONGOCORE Haeckel
SPONGOCORE PUER Campbell and Clark

Spongocore (*Spongocorissa*) *puer* CAMPBELL and CLARK, 1944, Geol. Soc. America, Spec. Paper No. 51, p. 22, pl. 3, figs. 7–9.

Specimens of this species correspond well with the original description. The species has been recorded from the Delmontian of southern California.

Genus CYPHONIUM Haeckel
CYPHONIUM FACETTARIUM Haeckel

Cyphonium facettarium HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 365.

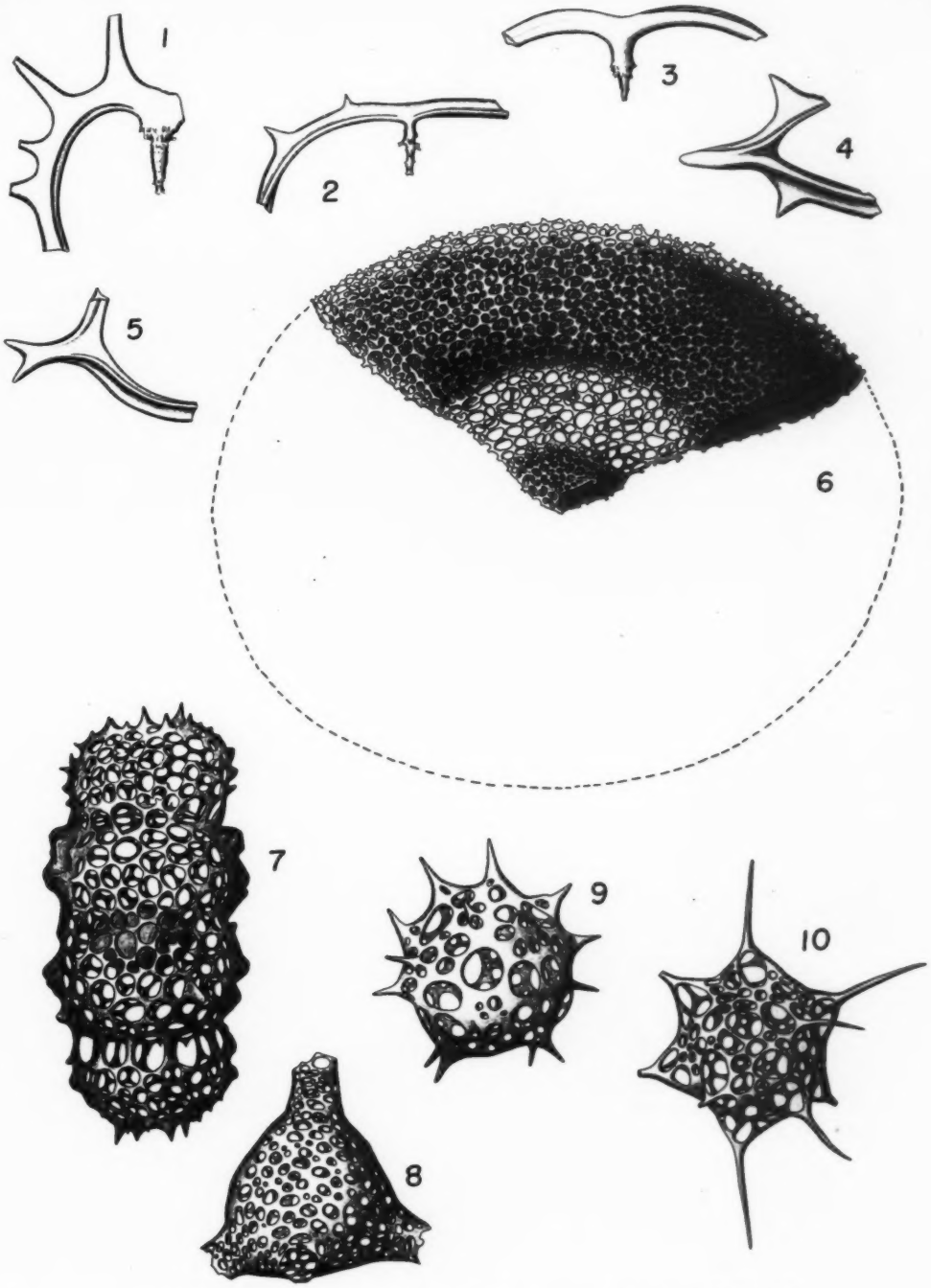
The specimens in the assemblage correspond well with Haeckel's description. This species has previously been recorded only from the western tropical Pacific.

Genus PANARTUS Haeckel
PANARTUS AVITUS Riedel, n. sp.
Plate 84, figure 7

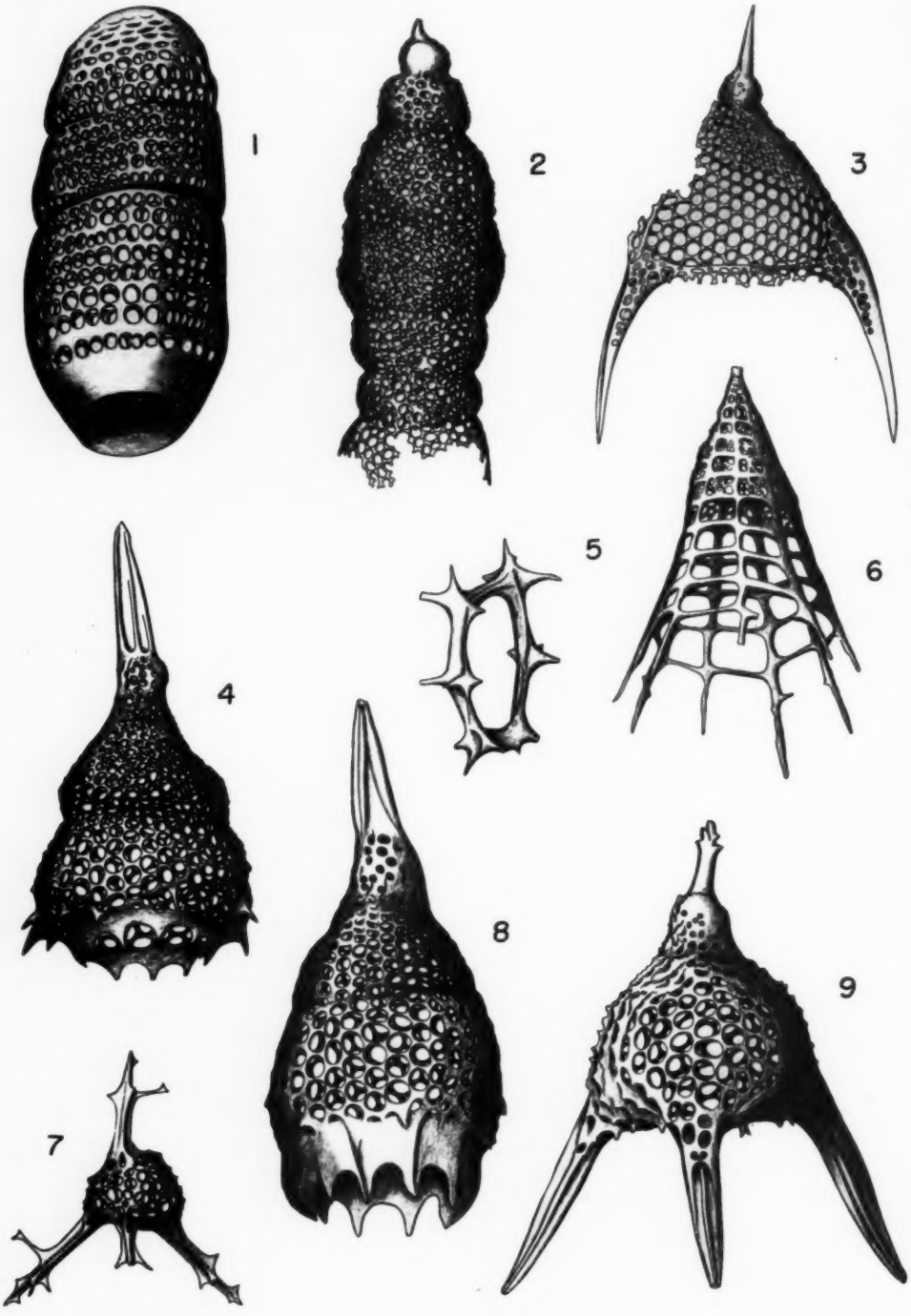
Four chambers of the cortical shell of

EXPLANATION OF PLATE 84

FIG. *1—? Spongosaturninus* sp., ×150. A fragment of the ring and radial spine. (p. 860)
2, 3—? Spongosaturnalis sp., ×150. Fragments of the ring and radial spines. (p. 806)
4, 5—? Saturnalis spp., ×150. Fragments of the rings with their accessory spines. (p. 806)
6—Spongodiscus communis fragilis Riedel, n. subsp. Holotype, ×350. Oblique view. Only a portion of the disc is drawn in detail, the outline of the remainder being indicated by the broken line. (p. 809)
7—Panartus avitus Riedel, n. sp. Holotype, ×370. (p. 808)
8—? Solenosphaera variabilis Haeckel, ×320. (p. 808)
9—? Acrosphaera sp. ×320. (p. 808)
10—? Acrosphaera inflata Haeckel, ×260. (p. 807)



Riedel, Mesozoic and late Tertiary Radiolaria of Rotti



Riedel, Mesozoic and late Tertiary Radiolaria of Rotti

similar general form, kidney-shaped (as in *Panartus tetrathalamus* Haeckel), except that the two distal chambers are somewhat smaller than the proximal pair. Pores of the proximal chambers subcircular, 3–6 times as broad as the intervening bars, 13–15 on a half equator, 7–9 on the length of a chamber. Walls of the proximal chambers bearing large, obtuse protuberances, 1.5–2 times as broad as the pores and half as long, usually concentrated on the widest part of the chambers. Pores of the distal chambers similar to those of the proximal, except for a row of larger pores at the junction with the latter. Surface of the distal chambers usually covered with short, acute, conical spines, approximately as long as the diameter of the pores. External medullary shell compressed, its greatest diameter half the equatorial diameter of the cortical shell; the inner medullary shell not clearly visible.

Total length of the shell 162–180 μ; of the apical spines 2–6 μ. Maximum breadth of the proximal cortical chambers 80–85 μ; of the distal cortical chambers 65–75 μ; of the equatorial constriction 70–75 μ; of the external medullary shell 32–35 μ.

This species differs from all others of the genus in the heavy protuberances on the proximal chambers of the cortical shell. Apart from this character, it corresponds closely to the cosmopolitan Recent species *Panartus tetrathalamus* Haeckel and *P. quadrijugus* Haeckel. There is also considerable similarity to *P. tetrameres* Haeckel from the late Tertiary of Caltanisetta, Sicily.

Genus HELIODISCUS Haeckel

HELIODISCUS ASTERISCUS Haeckel

Heliodiscus asteriscus HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 445, pl. 33, fig. 8.

Specimens occurring in the sediment from Rotti are quite typical. According to Haeckel, this species is cosmopolitan in the oceans of the present day.

Genus SPONGODISCUS Ehrenberg

SPONGODISCUS COMMUNIS Clark and Campbell FRAGILIS Riedel, n. subsp.

Plate 84, figure 6

Discoidal shell large, circular, with plain margin; thickened in the central portion and the outer region, with a thinner zone, composed of but one or two layers of meshes, between these thicker zones. Framework irregular, with five or six concentric annular rings in the central area; meshes everywhere irregularly polygonal, 3–5 times as broad as the bars. Diameter of the disc 250–300 μ; of the pores 4–10 μ.

This subspecies differs from the typical form (Clark and Campbell, 1942, p. 47, from the Eocene of Mt. Diablo, California) in that the thinner zone of the shell is more delicate, and the concentric rings of the central region are generally better defined.

Genus TETRAPYLE Müller

TETRAPYLE QUADRILOBA (Ehrenberg)

Schizomma quadrilobum EHRENBERG, 1860, Monatsberichten der königlich preussischen Akademie der Wissenschaften zu Berlin, p. 815.
Tetrapyle quadriloba (Ehrenberg) HAECKEL, 1862, Monogr. d. Radiolarien, Berlin, p. 436.

This species is very common in the fauna from Rotti, and this fact is one of the strongest indications for a Pliocene or Pleistocene age of the fauna. *Tetrapyle quadriloba* is one of the most abundant Radiolaria in the seas of the present day, and it must have risen to this ascendancy during the latest Tertiary or early Quaternary. The only fossil records of the species are in the Pliocene of

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EXPLANATION OF PLATE 85

FIG. *1*—*Tricolocampe* (?) *polyzona* Haeckel, ×530. (p. 812)
2—*Eucyrtidium elongatum peregrinum* Riedel, n. subsp. Holotype, ×320. (p. 812)
3—*Pterocanium* sp., ×260. A shell with one foot and part of the thorax broken away, illustrating the general form, the nature of the feet, and the radial ribs in the thoracic wall. (p. 811)
4—*Lamprocyclas maritalis antiqua* Riedel, n. subsp. Holotype, ×260. (p. 811)
5—*Zygocircus triquetrus* Haeckel, viewed obliquely. ×320. (p. 810)
6—*? Bathropyramis woodringi* Campbell and Clark, ×150. (p. 810)
7—*Tripilidium cladopodium exiguum* Riedel, n. subsp. Holotype, ×320. (p. 810)
8—*Calocyclas margatensis* Campbell and Clark, ×260. (p. 811)
9—*Lychnodictyum audax* Riedel, n. sp. Holotype, ×260. (p. 810)

Calabria (Seguenza, 1880, p. 231) and in the Tortonian of Sicily (Stöhr, 1880, p. 89).

Genus LARCOSPIRA Haeckel
LARCOSPIRA QUADRANGULA Haeckel

Larcospira quadrangula HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 696, pl. 49, fig. 3.

Specimens of this species in the sediment from Rotti are quite typical. The species was originally described from the central Pacific, apparently from Recent sediments.

Genus ZYGOCIRCUS Bütschli
ZYGOCIRCUS TRIQUETRUS Haeckel
Plate 85, figure 5

Zygocircus triquetrus HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 947, pl. 81, fig. 3.

The sediment from Rotti contains typical examples of this species, which Haeckel records as being cosmopolitan in the surface waters of the present oceans. It has not previously been recorded from fossil assemblages.

Genus EUCORONIS Haeckel
EUCORONIS ANGULATA Haeckel

Eucoronis angulata HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 978, pl. 82, fig. 3.

Typical specimens of this species occur in the fauna. The form was described by Haeckel from the central Pacific, presumably from Recent sediments.

EUCORONIS NEPHROSPYRIS Haeckel

Eucoronis nephrospyris HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 977, pl. 82, fig. 5.

The specimens occurring in the sediment from Rotti are quite typical. This species is cosmopolitan in the oceans of the present day, and has not previously been found fossilized.

Genus TRIPILIDIUM Haeckel
TRIPILIDIUM CLADOPODIUM Haeckel EXIGUUM Riedel, n. subsp.
Plate 85, figure 7

Shell approximately hemispherical, with rough surface, having 60–70 pores of varying sizes, 1.5–6 times as broad as the thin intervening bars. Apical horn three-bladed, acute, bearing few simple or branched secondary spines which arise from the blades in the distal half of the spine. Three strongly divergent feet arising from the base of the shell, of approximately the same length as the apical horn, and resembling it in shape, bearing 4–7 simple or branched secondary spines. Mouth somewhat constricted.

Height of the shell 32–40 μ; breadth 45–52 μ. Length of the apical horn 40–65 μ; of the basal feet 40–55 μ.

This subspecies is similar in form to Haeckel's species but it is constantly smaller, and the pores are larger in relation to the intervening bars. Haeckel records the species from the central Pacific, presumably from Recent sediments.

Genus BATHROPYRAMIS Haeckel
? BATHROPYRAMIS WOODRINGI Campbell and Clark
Plate 85, figure 6

Bathropyramis woodringi CAMPBELL and CLARK, 1944, Geol. Soc. America, Spec. Paper No. 51, p. 39, pl. 5, fig. 21, 22.

Specimens which are tentatively assigned to this species are not uncommon in the assemblage. None of the examples observed is complete at the apex, and thus it is not possible to determine definitely whether the form possesses a separate cephalis or apical spine: however, it seems probable that neither of these were present in the entire skeleton, as the broken edge of the apex indicates that it is composed of a simple, thin-walled cap. The specimens described by Campbell and Clark have eight radial beams, whereas those in the Rotti fauna have either eight, or more commonly, nine. In other respects, the present specimens correspond well with the type examples.

The only previous record of this species is from the Malaga mudstone (Delmontian) of southern California.

Genus LYCHNODICTYUM Haeckel
LYCHNODICTYUM AUDAX Riedel, n. sp.
Plate 85, figure 9

Shell campanulate, with rough surface and distinct collar stricture. Length of the two joints 1:4, breadth 1:5. Cephalis subspherical, with rather few, subcircular, well-separated pores, bearing a conical horn of

the same to twice the length, which has short, obtusely conical protuberances in its distal portion. Thorax subglobular, with rough ridges between the large rounded pores, which are 2–5 times as broad as the intervening bars. Peristome constricted, the feet arising slightly above the margin. Feet of approximately the same length as the thorax, triangular pyramidal with pronounced blades, fenestrated in the proximal portion, almost straight, divergent. Small spines are often present on the lower edge of the thorax, as if remnants from a reduced abdomen.

Length of the apical horn 35–50 μ; of the cephalis 24–28 μ; of the thorax 90–105 μ; of the feet 75–110 μ. Breadth of the cephalis 25–30 μ; of the thorax 110–130 μ; of the thoracic pores 4–12 μ.

This species differs from all others of the genus in the nature of the apical horn, and in the globular thorax with constricted peristome. It is perhaps most closely related to living species such as *L. sethopodium* Haeckel and *L. wyvillei* Haeckel, which have been recorded from the south Atlantic and central Pacific, respectively.

Genus PTEROCANIUM Ehrenberg

PTEROCANIUM PRAETEXTUM (Ehrenberg)

Lychnocanium praetextum EHRENBERG, 1873, Abhandlungen der königlich Akademie der Wissenschaften zu Berlin, 1872, p. 297, pl. 10, fig. 2.

Pterocanium praetextum (Ehrenberg) HAECKEL, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 1330.

Specimens of this species occurring in the fauna are quite typical. The species was described by Ehrenberg from the bottom sediment between Zanzibar and the Comoro Islands, and was found by Haeckel off Ceylon, and by Cleve (1904) in the Arabian Sea.

PTEROCANIUM sp.
Plate 85, figure 3

As only fragments of this rather delicate species were found, a full description cannot be given.

The cephalis is small, spherical with few well-separated pores, and bears a conical horn of approximately twice the length. The thorax is probably almost pyramidal, with circular pores, regularly disposed, 3–5 times as broad as the narrow intervening bars. The radial ribs in the thorax are well defined as solid rods, but are not raised above the shell surface. The feet are approximately as long as the thorax, divergent, proximally fenestrated, with convex back. Only traces of the abdomen are preserved, but it appears that it cannot have been long (perhaps 0.25 as long as the thorax). Total length of the figured specimen 250 μ.

This form is of interest stratigraphically, for although species resembling it are common in the seas of the present day (*Pterocanium eucolpum* Haeckel and *P. trilobum* Haeckel), they have not been found fossilized except in the Pliocene of Calabria (*P. diceras* Seguenza, 1880).

Genus CALOCYCLAS Ehrenberg

CALOCYCLAS MARGATENSIS Campbell and Clark
Plate 85, figure 8

Calocyclas margatensis CAMPBELL and CLARK, 1944, Geol. Soc. America, Spec. Paper No. 51, p. 47, pl. 6, figs. 17, 18.

The examples of this species in the fauna vary a little from the description given by Campbell and Clark, but these differences are not of sufficient magnitude or constancy to justify the erection of a new species or subspecies. In some specimens (pl. 85, fig. 8) the peristomial region is heavily silicified, in contrast to the thin wall of the distal part of the abdomen described by Campbell and Clark. Also, small thorns are often developed on the lower part of the abdomen; this may also be the case in the specimen figured by Campbell and Clark on their plate 6, figure 17, although it is not mentioned in the text.

This species has previously been recorded from the Miocene of California, and from a late Tertiary western Pacific sediment (Riedel, 1952).

Genus LAMPROCYCLAS Haeckel

LAMPROCYCLAS MARITALIS Haeckel ANTIQUA Riedel, n. subsp.
Plate 85, figure 4

Shell a little rough, campanulate, with indistinct collar, but pronounced lumbar stricture. Approximate proportions of the lengths of the segments 2:5:5; their breadths 1:4:5. Cephalis spherical, with about 25

well-separated circular pores, and bearing a thick three- or four-edged apical spine almost half as long as the shell. Thorax conical in the apical section, inflated below, having closely-spaced circular pores 3–4 times as broad as the intervening bars: 12–15 pores on a half equator in the widest part of the thorax, and a similar number in a vertical series. Abdomen slightly inflated, its pores 1.5–2 times as large as those of the thorax, bearing the same relation to the intervening bars as those of the latter, and arranged in indefinite vertical series of 6–8 pores each. Outer coronal of the peristome not well-developed, consisting of 8–15 thorns arising from the abdomen above, or in the upper portion of, the peristomial lamella. Inner coronal with 9–11 somewhat convergent triangular teeth, arising from the lower edge of the peristomial lamella, which is approximately as wide as an abdominal pore.

Length of the horn 65–70 μ; of the cephalis 24–26 μ; of the thorax 60–65 μ; of the abdomen 60–70 μ; of the peristomial teeth 5–10 μ. Breadth of the cephalis 24–26 μ; of the thorax 95–105 μ; of the abdomen 115–130 μ.

This subspecies differs from *Lamprocyclas maritalis* Haeckel, originally described from the central Pacific, in having more pores, more closely and regularly arranged, and thinner shell-wall. Also, the thorax is more definitely campanulate; although specimens of *L. maritalis* described by Haecker (1908, pp. 455, 456) from the northern Indian Ocean approximate it in this character.

Genus Tricolocampe Haeckel
Tricolocampe ? polyzona Haeckel
Plate 85, figure 1

Tricolocampe polyzona Haeckel, 1887, Rept. Sci. Results H.M.S. *Challenger*, Zool., vol. 18, p. 1412, pl. 66. fig. 19.

The few observed specimens of this form all had fewer rows of pores on the thorax and abdomen than indicated in the original description, but otherwise they are quite typical.

The species was found by Haeckel in the central Pacific, and "fossil in the Nicobars and in Barbados." In the sediments of the Swedish Deep Sea Expedition, it was found to be widespread in the Recent sediments of the tropical Pacific and Indian Oceans (Riedel, 1952).

Genus Lithomitra Bütschli
Lithomitra bramlettei Campbell and Clark

Lithomitra (*Lithomitrissa*) *bramlettei* Campbell and Clark, 1944, Geol. Soc. America, Spec. Paper No. 51, p. 53, pl. 7, figs. 10–14.

A few typical examples of this species were found in the assemblage. The species has previously been recorded only from the Miocene of southern California.

Genus Eucyrtidium Ehrenberg
Eucyrtidium elongatum Stöhr peregrinum Riedel, n. subsp.
Plate 85, figure 2

Shell with seven (or more) segments distinctly separated by constrictions, the first four segments together forming a conical section, the subsequent segments an approximately cylindrical section. Cephalis subspherical, rough, poreless, and bearing, usually eccentrically, a straight or curved conical horn of the same length. Thorax hemispherical, with rough surface, having some 40 subcircular pores, which are irregularly arranged and 1.5–3 times as broad as the intervening bars. Third segment conical, usually longer than any other, and fourth segment a cylinder bulged laterally to a greater or less degree; these two segments with rough surface, and circular pores 2–4 times as broad as the bars, often regularly arranged in indistinct vertical series, 7–9 in a vertical row on each segment, 14–20 on a half equator. Segments subsequent to the fourth are generally shorter and narrower than the third and fourth, subcylindrical, and laterally bulged: their surfaces are smooth, with irregularly disposed subcircular pores, 2–5 times as broad as the bars. The entire apertural margin of the shell was not observed, though it might be expected to be not greatly constricted, without radial apophyses.

Length of the first four segments 125–135 μ; greatest breadth (in the lower part of the third segment, or the middle of the fourth) 70–80 μ. Breadth of cephalis 20 μ; of thorax 35–40 μ; of fifth segment 60–65 μ. Length of cephalis 12–15 μ; of thorax 20–25 μ; of third

segment 35–50 μ; of fourth segment 30–40 μ; of subsequent segments 20–45 μ.

This subspecies differs from *Eucyrtidium elongatum* Stöhr (1880, p. 105, pl. 4, fig. 10) in that the pores are larger, and those on the third and fourth segments are more regularly arranged. Also, the third segment is usually conical, rather than subcylindrical.

This form is one of the more abundant in the assemblage, and has considerable stratigraphic significance. Species of *Stichocorys*, and of *Eucyrtidium* having characters tending towards *Stichocorys*, are common in the Miocene sediments of Sicily (Stöhr, 1880), Italy (Vinassa de Regny, 1900, and Luchesse, 1933), and California (Campbell and Clark, 1944a). Forms which are abundant in the upper Miocene, such as *Eucyrtidium delmontense* Campbell and Clark and *Stichocorys saccoi* Vinassa, have a conical section formed by the upper three segments, which is sharply delineated from the cylinder formed by the subsequent segments. *Eucyrtidium elongatum* Stöhr, from the Tortonian, and the subspecies here described, have four segments forming the conical section, and the break between this and the cylindrical section is not always pronounced. *Eucyrtidium elongatum peregrinum* may represent a transitional stage to a Recent form such as *Eucyrtidium cienkowskii* Haeckel.

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JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, PP. 814–816, PL. 86, TEXT FIG., NOVEMBER 1953

THE GONIATITE GENUS *PROLECANITES* IN AMERICA

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ABSTRACT—As now interpreted, the genus *Prolecanites* has only one American representative, *P. americanus* Miller and Garner, n. sp., from the Salem limestone of Indiana.

VARIOUS authors have restricted the scope of the genus *Prolecanites* Mojsisovics, 1882, so that at present none of the previously described American forms are referable to it. However, the John Britts Owen collection at the State University of Iowa contains three conspecific specimens from Indiana that are almost certainly congeneric with the type species of this genus. All of these are lithologically very similar, being composed of a distinctive light-brown oolitic limestone, and the label which accompanies them indicates that they were collected long ago at or near Greencastle, in west-central Indiana. Professor J. J. Galloway of Indiana University has written us that the only oolitic limestone which occurs in the neighborhood of Greencastle is the Salem, and presumably these goniatites came from that formation, which crops out to the north and east of the city.

Although there has been much difference of opinion in regard to the genotype of *Prolecanites*, it now seems clear that the type is the form from the Viséan of west-central Germany that was illustrated and described by G. and F. Sandberger (1850, pp. 67–68, pl. 3, figs. 13, 13a, 13b? [not pl. 9, fig. 6, but probably part of pl. 9, fig. 6a]) as *Goniatites mixolobus* Phillips. Mojsisovics (1882, p. 199) long ago pointed out that this German form is not referable to Phillips' English species, and therefore Miller (1938, p. 181) proposed the name *Prolecanites mojsisovicsi* for it.[1] Insofar as one can tell from the available data in regard to this type species, the genus should include subdiscoidal goniatites with open umbilici and external sutures that consist of a small ventral lobe and on either side of it four pointed linguliform lobes and four rounded saddles (with a fifth saddle centering near the umbilical seam). In most, if not all, of the species that appear to belong in this genus, the ventral lobe and the one on each side of it are smaller than the lobes immediately dorsad of them. This fact suggests that the three ventralmost lobes may have arisen by a trifurcation of a ventral lobe after the formation of first lateral lobes; and that the second bilateral pair of lobes dorsad of the ventral lobe, which are the largest, are the first lateral lobes. We have not been able to prove or disprove this hypothesis from a study of the literature or the specimens available to us. In the eastern hemisphere representatives of this genus are now known from at least Germany, England, Algeria, Yugoslavia, and possibly Spain and Soviet Russia (Kazakhstan); and all of them are believed to be of about the same general age, that is, Viséan. The one known from Algeria (see Dollé, 1912, pp. 251–254, pl. 7, figs. 1, 1a) is the type of Schindewolf's genus *Metacanites*, which as believed by Schmidt (1925, p. 537) but not Librovitch (1940, pp. 85, 250–251) should be suppressed as a synonym of *Prolecanites*—the specific affinities of this Algerian form are uncertain, and a name should probably be proposed for it. Furthermore, as noted by Miller and Furnish (1940, p. 371) and others, *Paraprolecanites* Karpinsky, 1889, is most probably a synonym of *Prolecanites*, though possibly its genotype will have to be the species represented by the small fragment illustrated by figure 6 [and all or part of figure 6a] on the Sandberger brothers' plate 9 of 1850, in which case it is not likely that the affinities of the genus can be determined with certainty.

[1] Miller did not include the crushed specimen represented by figure 13b on the Sandberger brothers' plate 3 of 1850; and through a misprint he referred to "figs. 3, 3a" rather than figs. 13, 13a.

The three American specimens under consideration are clearly conspecific, but they do not appear to be referable to any established species. Accordingly, we are here proposing a name for them.

PROLECANITES AMERICANUS Miller and Garner, n. sp.
Plate 86, figures 5, 6

All the specimens on which this species is being based are completely septate internal molds that are moderately well preserved. Though they are incomplete, they are essentially free from distortion. One of the three represents only the inner whorls of the conch, whereas each of the others has an over-all diameter of about 45 mm. The better of the two large individuals is illustrated on the accompanying plate, and it is being chosen as the holotype.

The conch is subdiscoidal in shape as the whorls at maturity are higher than wide and are subquadrate in cross section, being flattened laterally, very broadly rounded ventrally, and only slightly impressed dorsally. The flattened lateral zones are essentially parallel, and the ventrolateral and dorsolateral shoulders are rounded. Near the adoral end of the holotype, the height and corresponding width of conch measure about 18 mm. and 12½ mm., respectively, and the dorsal impressed zone is less than 1 mm. deep.

The umbilicus is large, and the maximum diameter of that of the holotype measures about 25 mm. The umbilical walls are rounded, and in the adoral portion of the holotype their width is some 5 mm. No trace of surface markings can be discerned on any of the type specimens. However, their preservation is such that faint markings would most probably not have been retained.

As shown by the accompanying text figure, each mature external suture consists of a small acuminate ventral lobe with almost parallel flanks, and on either side of it four pointed lobes and five rounded saddles. The lobe just outside the umbilical seam is small and more or less V-shaped, whereas all of the others (except the ventral) are pointed linguliform. The precise nature of the internal suture was not ascertained, but it can be seen that each consists of a large dorsal lobe and on either side of it a smaller internal lateral lobe (one flank of which extends across the umbilical seam). Each complete mature suture therefore consists of a total of twelve lobes and twelve saddles. In at least the external portions of the sutures, all the lobes are pointed and all the saddles are rounded.

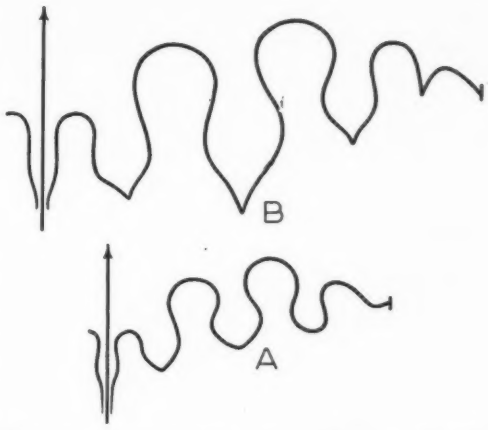

FIG. 1—Diagrammatic representations of (A) early and (B) fully mature external sutures of *Prolecanites americanus* Miller and Garner, n. sp., of the Salem limestone of Indiana, ×9 and ×3, respectively; based on the holotype at heights of conch of about 4 mm. and 16 mm. Drawn by Charles Collinson.

Remarks.—In none of the forms that belong in *Prolecanites* s.s. has the early ontogenetic development of the sutures been ascertained. Therefore, an attempt was made to separate the individual whorls of our smallest specimen, but no trustworthy data were secured because of poor preservation. In the earliest stage of development that we were able to observe on our specimens, the ventral portion of the sutures does not differ essentially from that on the adoral part of our large individuals (cf. A and B of text fig. 1). In this species, the general course of the sutures seems to be a little more arcuate than in the Eurasian and African forms, but this difference may well be more apparent than real and probably is not very significant.

Unfortunately, the genotype is so poorly known that satisfactory comparisons of *P. americanus* and it are not possible, and this statement is also applicable to all the

other Eurasian forms. It can, however, be said that in the Yugoslavian species, *P. quinquelobus* Kittl, the umbilicus is comparatively small and the sutures are somewhat farther advanced. The Algerian form has a relatively narrow conch that is more narrowly rounded ventrally, and its sutures are also somewhat farther advanced than are those of our species.

Occurrence.—Salem limestone at or near Greencastle, Putnam County, Indiana.

Type.—State University of Iowa, 13889.

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EXPLANATION OF PLATE 86

(Photographs retouched by Len Everett and Howard Webster)

FIGS. *1, 2*—*Anthracoceras? argentinense* Miller and Garner, n. sp. Two views of the holotype, from the upper part of the "Sistema de Tepuel" (Middle Pennsylvanian) at or near La Carlota, Chubut, Argentina, ×1½. (p. 822)

3, 4—*Eoasianites* sp. Two views of a specimen from the same general horizon and locality as the preceding but some 200–250 meters higher stratigraphically, ×3. (p. 821)

5, 6—*Prolecanites americanus* Miller and Garner, n. sp. Two views of the holotype, from the Salem limestone at or near Greencastle, Indiana, ×1½. (p. 815)

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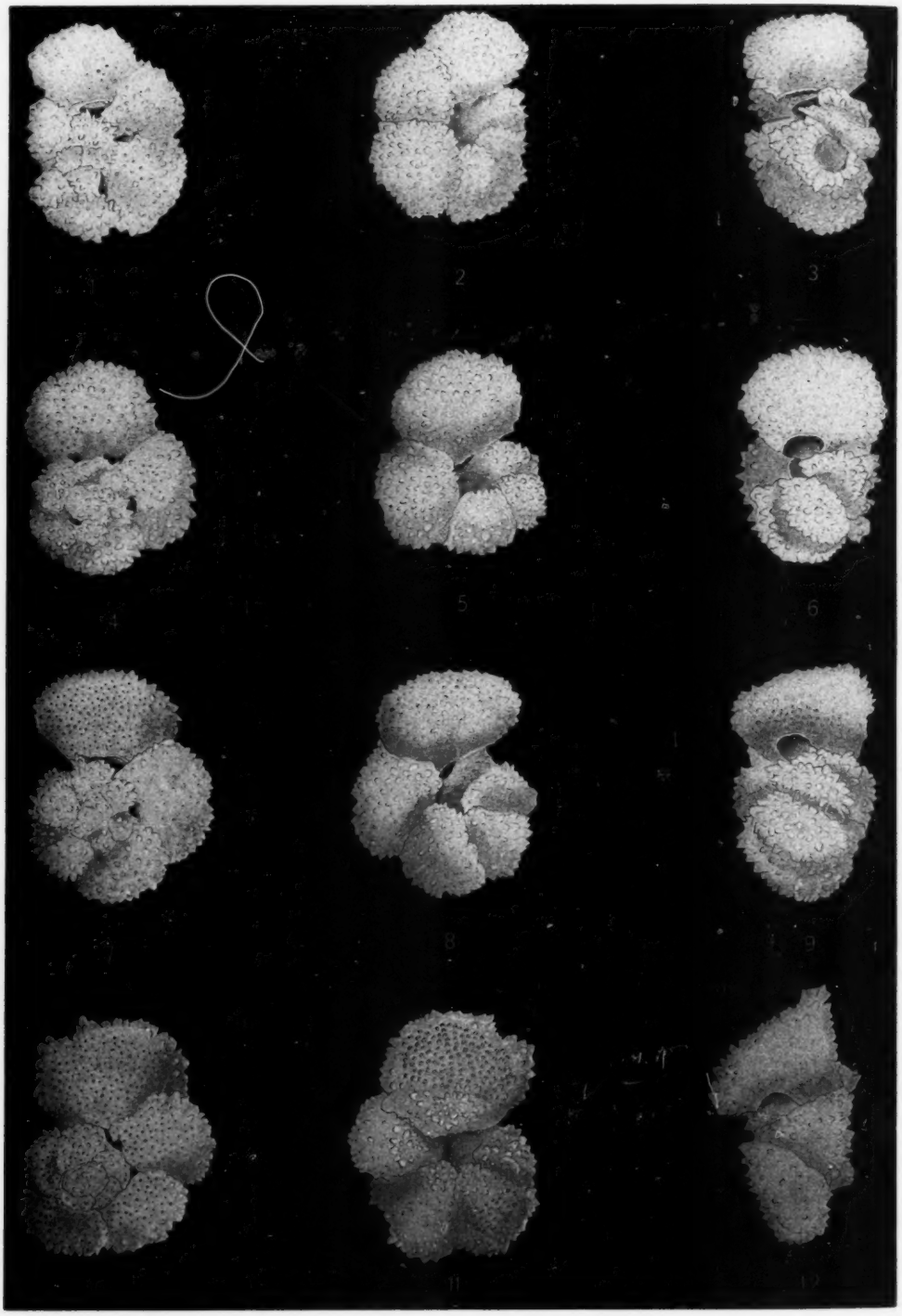
Miller and Garner, Goniatite genus *Prolecanites* in America



Bronnimann and Bermudez, New foraminiferal genus from Eocene of Trinidad

JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, PP. 817–820, PL. 87, NOVEMBER 1953

TRUNCOROTALOIDES, A NEW FORAMINIFERAL GENUS FROM THE EOCENE OF TRINIDAD, B.W.I.

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Truncorotaloides belongs to the biostratigraphically important, heavy spinose planktonic Foraminifera recorded in Trinidad from the Paleocene to the upper Eocene (Cushman and Renz, 1942, 1946, 1948; Bronnimann, 1952). The new genus differs from *Truncorotalia* Cushman and Bermudez, 1949, recently given generic rank (Bermudez, 1952, p. 54), by additional small sutural openings at the spiral side. In respect to these supplementary openings, the same relationship exists between *Truncorotalia* and *Truncorotaloides* as between *Globigerina* d'Orbigny, 1826, and *Globigerinoides* Cushman, 1927.

The plano-convex test of *Truncorotaloides* shows in apertural view a rounded-subangular to distinctly angular outline, a feature which is considered to be taxonomically subordinate to the general form of the test and the type and arrangement of the aperture and accessory apertures. The specimens with a rounded outline in apertural view could also be regarded as representatives of *Globigerinoides*, having developed a high degree of structural similarity with *Truncorotaloides*. But in view of the association of the rounded, subangular and angular specimens in the same population, and the occurrence of intermediate forms, the *Globigerinoides*-like specimens are here assigned to *Truncorotaloides*. The four forms described in the following are treated as varieties, which would become subspecies if future work should prove their stratigraphic ranges to be different.

Family ROTALIIDAE
Subfamily GLOBOTRUNCANINAE
Genus TRUNCOROTALOIDES Bronnimann and Bermudez, n. gen.

Genotype.—*Truncorotaloides rohri* Bronnimann and Bermudez.

Diagnosis.—Test a low trochoidal plano-convex spiral of two volutions. Final volution contains five to six chambers, not overlapping, or overlapping at spiral side only. Chambers subglobular throughout or subglobular in early and subangular in late ontogenetic stage or angular throughout. Spiral side slightly convex to almost flat, umbilical side slightly to strongly convex. Sutures straight to curved in direction of coiling. Umbilicus deep and small. Apertures large, arcuate, with lip-like borders, directed into umbilicus. Small, arcuate to slit-like additional sutural openings at spiral side. Surface with heavy spines. Walls finely perforate. Direction of coiling predominantly sinistral.

Discussion.—The new genus differs from *Truncorotalia* by the supplementary openings at the spiral side; from *Globigerinoides*

EXPLANATION OF PLATE 87

FIGS. *1–3*—*Truncorotaloides rohri* var. *guaracaraensis* Bronnimann and Bermudez, n. sp., n. var. T.L.L. Cat. No. 172694, Eocene, Trinidad, B.W.I. Approx. ×80. Spiral, umbilical, and apertural views. Holotype. (p. 819)

4–6—*Truncorotaloides rohri* var. *piparoensis* Bronnimann and Bermudez, n. sp., n. var. T.L.L. Cat. No. 172694, Eocene, Trinidad, B.W.I. Approx. ×80. Holotype. p. 819)

7–9—*Truncorotaloides rohri* Bronnimann and Bermudez, n. sp., T.L.L. Cat. No. 172694, Eocene, Trinidad, B.W.I. Approx. ×80. Holotype. (p. 818)

10–12—*Truncorotaloides rohri* var. *mayoensis* Bronnimann and Bermudez, n. sp., n. var. T.L.L. Cat. No. 172694, Eocene, Trinidad, B.W.I. Approx. ×80. Holotype. (p. 820)

which possesses "numerous, large, supplementary apertures around the margin of the chamber," by the low trochoidal, planoconvex test and the characteristic heavy spinose ornamentation. The heavy spines of *Truncorotaloides* are permanent protuberances of the test. Further, *Truncorotaloides* is restricted to the Eocene, whereas *Globigerinoides* is known from the Eocene ?, possibly Oligocene to Recent.

Occurrence.—The material (sample K.R. 23842, T.L.L. Cat. No. 172694) originates from a marl pebble bed situated in the Duff road area, near Kelly junction, about seven miles east of Pointe-à-Pierre, central Trinidad. The larger components of this bed, consisting of subangular to rounded marl pebbles of Eocene and Oligocene age, are embedded in a finely pebbly heterogeneous matrix of predominantly Oligocene origin. The new pelagic Foraminifera were encountered only in the heterogeneous matrix, thus their exact stratigraphic significance is not known. However, it can be assumed from the vertical distribution of the spinose Globigerinas and Truncorotalias, that *Truncorotaloides* can only be of Paleocene to upper Eocene age. No such forms are known from the Oligocene. The absence in the Trinidad Paleocene of species related to *Truncorotaloides*, and the lower Eocene age of the oldest components of the marl pebble bed, suggest that a Paleocene age can be excluded.

Outside Trinidad, *Truncorotaloides* has been encountered in Cuba, where typical representatives of *Truncorotaloides rohri* and its varieties occur abundantly in a lower to middle Eocene marl at Jaruco, Province of Habana (P. Bronnimann, private collection) and, according to Dr. Bermudez, in samples from the type locality of the Guayabal formation, State of Vera Cruz, Mexico.

TRUNCOROTALOIDES ROHRI Bronnimann and Bermudez, n. sp.
Plate 87, figures 7–9

Description.—The low trochoidal test has a distinctly lobate outline. The spiral side, excepting the central portion, is almost flat and shows two volutions with about 13 chambers. The last whorl has five chambers. The early chambers are subglobular, appressed, the adult ones flat at the spiral side, subangular to angular and separated by strong peripheral incisions. The chambers of the final volution are overlapping. The umbilicus is deep and rather small. The sutures of the early portion of the test appear to be straight, the later ones are slightly curved in direction of coiling. The apertures of the two last chambers are large arcuate, open directly into the umbilicus, and are provided with minute lip-like borders. The preceding apertures are not visible. Small arcuate additional openings with minute lip-like growths pierce the spiral side of the last two chambers at the intersection of radial and spiral sutures. It is not known whether this type of opening is also present in the early ontogenetic stage. The surface is ornamented with heavy spines, which are strongly developed on the initial chambers, on the pointed umbilical portions, and along the subangular edges of the adult chambers. The spines are rare and small in the vicinity of the apertures and on the flat spiral side of the last chambers. The walls are finely perforate. Seven out of eight specimens coil to the left.

Discussion.—This form has been chosen as central type of the group. It is intermediate between the angular and the subangular to rounded types. The test of *Truncorotaloides rohri* resembles somewhat *Truncorotalia crassata* (Cushman). However, paratypes of this species from Moctezuma River, Hacienda Romance, State of Vera Cruz, Mexico, collected by Earl Oliver, kindly lent for comparison by the U. S. National Museum, do not possess additional sutural openings; the same is true for specimens of *T. crassata* (Cushman) from the Guayabal formation, Mexico, obligingly donated by W. Storrs Cole, Ithaca.

The new species is named for K. Rohr in recognition of his contribution to the geology of the Central Range of Trinidad.

Dimensions.—Maximum diameter of test 0.425 mm. End chamber: radial diameter 0.15 mm., tangential diameter 0.275 mm., height 0.250 mm. Diameter of aperture about 0.075 mm., of additional spiral openings 0.050 mm.

Holotype.—T.L.L. Cat. No. 172694. De-

posited in the Cushman Collection, U. S. National Museum, Washington, D. C.

TRUNCOROTALOIDES ROHRI var. GUARACARAENSIS Bronnimann and Bermudez, n. sp., n. var.
Plate 87, figures 1–3

Description.—The general outline of the low trochoidal test is almost ellipsoid. The slightly convex spiral side shows ten to eleven chambers arranged in two volutions. The adult test has five to six chambers. The appressed subglobular chambers increase gradually in size. The chambers of the final whorl, in particular the end chamber, are peripherally flattened in side view. The umbilicus is rather small and deep. The straight sutures are well marked in the adult, but indistinct in the strongly spinose young ontogenetic stage. The large arcuate apertures of the last two chambers open directly into the umbilicus. Those of the preceding chambers are not known. The apertures are surrounded by thin lip-like borders. At the spiral side, additional, small, arcuate openings with minute lip-like borders pierce the three last-formed chambers at the intersections of radial sutures and periphery of the preceding volution. It is not known whether openings of this type exist in earlier chambers. The surface is uniformly covered by small, heavy spines, which are strongly developed on the early chambers and at the rounded umbilical parts of the adult chambers. The walls are thick and perforate. Nineteen out of 21 well-preserved specimens are sinistrally coiled.

Discussion.—*Truncorotaloides rohri* var. *guaracaraensis* is the variety with completely rounded chambers; this form could be interpreted as *Globigerinoides*. Transitions connect this variety and the more lobate and subangular *K. rohri* var. *piparoensis*. The tests can be arranged in two groups of slightly different maximum diameter. The holotype belongs to the larger tests. The variety is named after the Guaracara River, central Trinidad.

Dimensions.—Maximum diameter of test 0.375 mm. End chamber: radial diameter 0.125 mm., tangential diameter 0.2 mm., height 0.215 mm. Diameter of aperture 0.05–0.08 mm., of additional spiral opening 0.05 mm.

Holotype.—T.L.L. Cat. No. 172694. Deposited in the Cushman Collection, U. S. National Museum, Washington, D. C.

TRUNCOROTALOIDES ROHRI var. PIPAROENSIS Bronnimann and Bermudez, n. sp., n. var.
Plate 87, figures 4–6

Description.—The general outline of the low trochoidal test is lobate. The slightly convex spiral side shows two volutions with about 11 chambers. The adult test is five-chambered. The chambers are subglobular and appressed in the early stage; later chambers become subangular and flattened at the spiral side. In the adult, the straight sutures are deep and the chambers are well separated. The large arcuate apertures of the last two chambers open directly into the umbilicus. They are surrounded by minute lip-like borders. The spiral side shows four small additional arcuate openings with minute lip-like borders at the intersections of radial and spiral sutures. The end chamber is pierced by two sutural openings. It is not known whether this type of opening is confined to the adult. The surface is uniformly spinose. The initial portion and the umbilical parts of the adult chambers are strongly spinose, whereas the spines are scarcer and smaller on the flattened surface of the last two chambers. The walls are finely perforate. Four out of five well-preserved specimens are sinistrally coiled.

Discussion.—The test is intermediate between the completely rounded variety *guaracaraensis* and the central type *rohri*. It differs from *T. rohri* var. *guaracaraensis* by the more lobate outline, the slightly subangular and spirally flattened adult chambers, and by the differentiation in the development of the spines. The variety is named after Piparo River, central Trinidad.

Dimensions.—Maximum diameter of test 0.387 mm. End chamber: radial diameter 0.175 mm., tangential diameter 0.250 mm., height 0.275 mm. Diameter of aperture about 0.075 mm.

Holotype.—T.L.L. Cat. No. 172694. Deposited in the Cushman Collection, U. S. National Museum, Washington, D. C.

TRUNCOROTALOIDES ROHRI var. MAYOENSIS Bronnimann and Bermudez, n. sp., n. var.
Plate 87, figures 10–12

The general outline of the low trochoidal test is lobate. The almost flat spiral side shows about 11 chambers arranged in two volutions. The five chambers of the final volutions are overlapping, angular, flat at the spiral side and pointed toward the umbilicus. The shape of the early chambers is not known. The umbilicus is deep and small. The sutures are curved in the direction of coiling. The large arcuate aperture of the end chamber is surrounded by a minute lip-like border, and directed into the umbilicus. The earlier apertures are not known. Small, slit-like additional openings occur at the spiral side of the last two chambers at the intersections of radial sutures and the periphery of the preceding volution. These openings are also provided with small lip-like borders. It is not known if such openings exist in the earlier stage. The surface is ornamented by heavy spines which are strongly developed on the initial portion and along the edges and at the pointed umbilical portions of the adult chambers. The flat spiral surfaces and the vicinity of the apertures are without or with rare and small spines only. The walls are perforate. Only two well-preserved specimens were encountered. Both coil to the left.

Discussion.—This variety is the extreme angular type of this group. It is named after the Mayo River, central Trinidad.

Dimensions.—Maximum diameter of test 0.45 mm. End chamber: radial diameter 0.187 mm., tangential diameter 0.288 mm., height 0.275 mm.

Holotype.—T.L.L. Cat. No. 172694. Deposited in the Cushman Collection, U. S. National Museum, Washington, D. C.

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JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, PP. 821–823, 2 TEXT FIGS, NOVEMBER 1953

UPPER CARBONIFEROUS GONIATITES FROM ARGENTINA

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ABSTRACT—Two rather well-preserved ammonoids are described from Chubut, in south-central Argentina. They are probably referable to the genera *Anthracoceras* and *Eoasianites* and are related to forms known from the Cherokee of Missouri.

EXCEPT in Australasia, Paleozoic ammonoids are indeed rare in the southern hemisphere. From all of South America we do not know a single Devonian or Lower Carboniferous goniatite, and only a few specimens have been found in the later Paleozoics. The upper Carboniferous of northwestern and central Peru has yielded a fauna (two genera) which is related to that of the Atoka and Winslow (early Middle Pennsylvanian) of Oklahoma and Arkansas. From northern Colombia, near the Venezuelan border, there is known a Leonard (early Middle Permian) fauna, which again consists of only two genera.

In 1948 Suero announced the discovery of goniatites in south-central Argentina, and through the courtesy of Dr. C. J. Stubblefield of the Geological Survey and Museum [of Great Britain], we were loaned the two specimens known from there. Although both of these are moderately well preserved, unfortunately they are not very diagnostic types. After careful consideration, we have concluded that most probably they belong in the genera *Anthracoceras* Frech and *Eoasianites* Ruzhencev, and that they are reminiscent of congeneric species that occur in central United States in the Cherokee (Middle Pennsylvanian).

Our identification and age-determination of these specimens differ materially from those published by Suero. Therefore, it should perhaps be emphasized that we have not seen the associated fauna and that comparable goniatites are known from strata that are a little older and a little younger than the Cherokee. Furthermore, although the two Argentine specimens came from a single locality, they are stated to have been collected from beds that are some 200 to 250 meters apart stratigraphically. Therefore our conclusion as to the age of the containing strata rests on none too secure a basis, and it should be regarded as tentative—of course, there may well be considerable difference in the age of these two individuals.

The larger of the two specimens under consideration (pl. 86, figs. 1, 2) has a maximum over-all dimension of about 38 mm., and it is completely septate and therefore represents only phragmocone. The conch is more or less helmet-shaped in cross section, being evenly rounded ventrally and laterally and impressed dorsally. The preserved portion of it is estimated to have attained a maximum height and width of conch of about 20 mm. and 25 mm., respectively; with the corresponding depth of the impressed zone being some 10 mm. The umbilicus is moderately small but is not closed, and the umbilical shoulders are broadly rounded and rather indefinite. No trace of any surface markings the test may have possessed is retained on this specimen, an internal mold preserved in dark-gray to black limestone. Each mature external suture (text fig. 1B) consists of a broad prominent ventral lobe (of which the prongs are of about the same magnitude as the intermediate saddle), and on either side of it a broad rounded U-shaped first lateral saddle, a V-shaped acuminate first lateral lobe, a low broadly rounded second lateral saddle, and a small subangular second lateral lobe which centers just inside the umbilical shoulder and which extends to the umbilical seam. As shown by text figure 1, this suture is quite similar to those of congeneric forms from the Boggy formation of Oklahoma and the Cherokee shale of Missouri (both of which are of about the same general age). We are tentatively placing all three of these species in Frech's genus *Anthracoceras*, but it should be emphasized that the status of that genus is not very

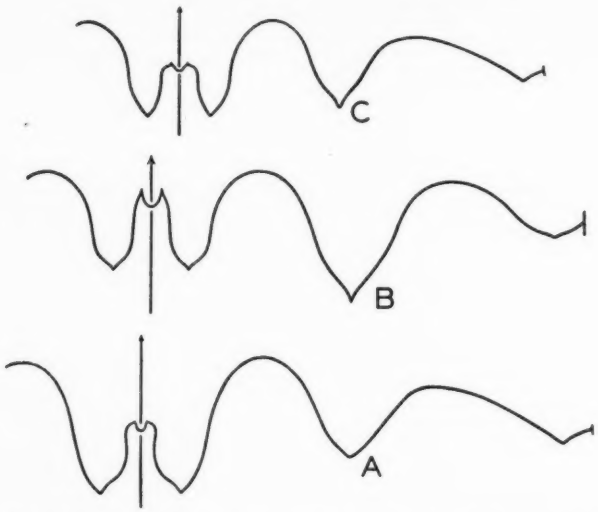

FIG. 1—Diagrammatic representations of mature external sutures of three species that probably belong in the genus *Anthracoceras* Frech: (A) *A.? missouriense* Miller and Owen of the Cherokee shale of Missouri, ×5; (B) *A.? argentinense* Miller and Garner, n. sp., of the "Sistema de Tepuel" of Chubut, ×2; and (C) *A.? oklahomense* Miller and Owen of the Boggy formation of Oklahoma, ×5. The second is based on the mid-portion of the outer volution of the holotype, which is portrayed by figures 1 and 2 on Plate 86.

satisfactory because so little detailed information is available in regard to its type species, which is from the early Upper Carboniferous near Katowice, Poland. Clearly the Argentine form is not conspecific with those known from either North America or Europe, and we are therefore proposing a name for it, *A.? argentinense.*

The smaller of the two Argentine goniatite specimens under consideration (pl. 86, figs. 3, 4) is also a completely septate internal mold which retains no trace of the surface markings of its test. The maximum diameter of the preserved portion of this individual measures about 19 mm. In at least the adoral part of the specimen, the whorls are low, being strongly depressed dorso-ventrally, broadly rounded ventrally and ventrolaterally, very narrowly rounded dorsolaterally (that is, on the umbilical shoulders), slightly convex on the umbilical walls, and not deeply impressed dorsally. It is estimated that near the adoral end of the specimen the height and width of conch are some 6 mm. and 13 mm., respectively; and the corresponding width of umbilicus and depth of impressed zone are of the order of 7 mm. and 2½ mm. As shown by text figure 2, each mature suture of this specimen consists of a bifid ventral lobe (of which the prongs are narrow, pointed, and acuminate, and the intermediate saddle is less than half as high as the lobe is deep), and on either side of this ventral lobe a high U-shaped first lateral saddle which is constricted laterally, a deep first lateral lobe which is sagittate

FIG. 2—Diagrammatic representation of a complete suture of the representative of the genus *Eoasianites* Ruzhencev that is portrayed by figures 3 and 4 on Plate 86, based on the adoral portion of the specimen, ×1.

and acuminate and is distinctly curved, a second lateral saddle which is only moderately high and is asymmetrical, a second lateral lobe which centers on the umbilical wall and is V-shaped and acuminate, a narrowly rounded internal second lateral saddle, a V-shaped internal first lateral lobe, and a U-shaped internal first lateral saddle which extends to a V-shaped dorsal lobe. Clearly this form belongs in Ruzhencev's genus *Eoasianites* and is fairly close to such species as *E. welleri* (Smith) of the Cherokee shale of Missouri and Kansas (and possibly the Middle Pennsylvanian of Illinois and Texas) and *E. angulatus* (Girty) of the Wewoka formation of Oklahoma (and possibly the Upper Pennsylvanian of Texas).

Both of the Argentine goniatites just discussed are from the upper part of the "Sistema de Tepuel" at or near La Carlota (Tecka), Chubut. Dr. C. J. Stubblefield has written us that in 1948 Dr. H. J. Harrington stated that the smaller specimen "comes from a level some 200 to 250 metres above the first [larger] one, at the same locality." The smaller individual appears to be from a siliceous nodule, and Suero (1948, p. 41) indicates that it was found in association with abundant well-preserved fossils, including corals, bryozoans, brachiopods, pelecypods, gastropods, conularids, nautiloids, trilobites, and fishes. The larger specimen is stated by Suero to have been found in a fragment of dark-gray limestone that doubtlessly came from the upper part of the "Sistema de Tepuel," which is very thick. Both specimens are at present on loan to the Geological Survey and Museum in London.

In concluding, we want to state that it is our considered opinion that the importance of the discovery of goniatites in Argentina can not be overemphasized. We would therefore like to urge that every effort be made to secure additional material, especially because this fauna seems to be slightly younger than the one known from the Upper Carboniferous of Peru.

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* See also the following publication, which appeared after our report was written:

SUERO, TOMAS, 1952, Las sucesiones sedimentarias Suprapaleozoicas de la zona extraandina del Chubut (Patagonia austral—Republica Argentina): Cong. Géol. Internat., XIX^e, Symposium sur les Séries de Gondwana, pp. 273–384.

JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, PP. 824–844, PLS. 88–91, 3 TEXT FIGS, NOVEMBER 1953

FACIES AND FAUNA IN THE BHADRAR BEDS OF THE PUNJAB SALT RANGE, PAKISTAN

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ABSTRACT—The upper layers of the Sakesar limestone (lower Eocene) of the western and central Salt Range pass eastward into the lower Bhadrar shales, reflecting an approach to the margin of the basin of deposition. The passage from limestone to shale is accompanied by changes in faunal phase which reflect a wide variation in reaction to change in environment by different elements of the foraminiferal faunas. Details of the changing succession and faunal assemblages are given at selected intervals along about 50 miles of the outcrop. Significant extensions to the previously recorded stratigraphical and geographical ranges of several foraminiferal species are recorded.

INTRODUCTION AND PREVIOUS WORK

IN A recent paper, Eames (1952) has recorded the general agreement of a considerable body of geological opinion that certain anomalies concerning the correlation of Eocene beds in Pakistan and India require elucidation. Eames' important work on standard sections throughout the region has demonstrated that many of the sub-divisions, which have been widely applied to the main series, have "no real and satisfactory basis" (Eames, 1952, p. 194). It is clear, however, from the work which has accumulated, and from the new standard sections, that much of the Eocene succession displays well-marked local lithological and paleontological zones. The extent and stratigraphical value of these local zones assume considerable practical importance in oil exploration and oil field development in the region, and it was in this connection that the author was, for several years, directed by the Attock Oil Company to undertake a detailed study of certain ranges of the Eocene succession in the Kohat-Potwar basin in northwest Pakistan. As indicated during the discussion of Eames' paper (1952, p. 198), one of the conclusions of this work was that the succession is subject to lateral changes of facies accompanied by changes in faunal phase. To the author's knowledge, this aspect of Eocene foraminiferal faunas in northwest India and Pakistan has not been extensively considered, and it is the object of this paper to place on record a clear example of the effect of facies on foraminiferal faunas.

The Cenozoic succession in the sedimentary basins of western Pakistan can be summarized as shown at top of page 825.

The beds described in the present paper are of Laki (lower Eocene) age, and the facies change occurs over approximately 50 miles of their outcrop in the eastern and central Salt Range (see fig. 2). In the eastern outcrops the highest Laki beds beneath the unconformable Murree (Miocene) freshwater beds are 50–80 feet of shales with thin limestones which overlie the main Laki (Sakesar) limestone and have been differentiated as a separate stratigraphic unit—the Bhadrar beds; a term which, according to Pinfold (1937, p. 12) was originally applied by Gee and Evans.

Only brief descriptions of the beds have been published. Cotter (1933, p. 96) reports "passage beds, shaly limestones, marls and shales, sometimes 20 feet thick or so, overlying the massive hill limestone" near Dhok Thalian.

Gee's description is as follows (1932, p. 116): "On the Salt Range plateau, between Khajurla and Khokhar, the Hill Limestones are overlain by from 50 to 80 feet of fine green shales and thin limestones with numerous foraminifera."

L. M. Davies records the following Foraminifera from the Bhadrar beds (1937, p. 15):

Assilina daviesi de Cizancourt
A. spinosa Davies
A. subspinosa Davies
Lockhartia tipperi (Davies)
Orbitolites complanatus Lamarck.

LOWER INDUS BASINS	KOHAT-POTWAR BASIN	AGE
MANCHAR SERIES (10,000 ft.) Freshwater, fluviatile clays, sandstones, conglomerates.	SIWALIK SERIES (17,000+ft.) Freshwater, mainly fluviatile clays, sands, conglomerates.	MIOCENE—PLEISTOCENE
GAJ SERIES (1,500 ft.) Marine limestones and shales. Freshwater sandstones.	MURREE SERIES (8,500 ft.) Mainly lacustrine, freshwater sandstones, shales.	MIOCENE
	unconformity	
NARI SERIES (6,000 ft.) Upper part fluviatile, mainly sandstones. Lower part marine limestone.	Absent	OLIGOCENE—L. MIOCENE
Unconformity		
TAPTI SERIES (500 ft.) Marine, mainly clays and shales.	Absent	U. EOCENE
KIRTHAR SERIES (3,000 to 9,000 ft.) Mainly marine limestones, shales. Freshwater clays near the base.	KIRTHAR SERIES (750 ft.) Marine limestones, shales. Freshwater horizon near the base.	M. EOCENE
LAKI SERIES (4,000 ft.) Marine shales, limestones. Desiccation phase at the top.	LAKI SERIES (600 ft.) Marine shales, limestones. Desiccation phase at the top.	L. EOCENE
	unconformity	
RANIKOT SERIES (2,000 ft.) Marine shales, limestones.	RANIKOT SERIES (1,000 ft.) Marine shales, limestones, sandstones, coals.	PALEOCENE
	unconformity	
Cardita beaumonti beds	Absent	DANIAN
CRETACEOUS	Absent	
JURASSIC, etc.	JURASSIC—CAMBRIAN	

He does not, however, give any details as to horizon or locality from which the fossils were collected.

To the above information, Evans has added (discussion in Davies, 1943, p. 78): "... the Bhadrar Beds themselves presented problems, as they were associated with a local unconformity, marked in places by a basal conglomerate."

TYPES

Specimens herein described have been deposited in the collections of the British Museum in South Kensington, under the registered numbers P 41510–P 41544 and E 40508–E 40509.

ACKNOWLEDGMENTS

F. E. Eames has given invaluable help and advice throughout the course of preparation and presentation of this paper. Criticism and suggestions from E. S. Pinfold, R. G. S. Hudson, and G. Cotton have eliminated a large number of errors. L. Noens photographed most of the specimens. To all the above, and to the directors of the Attock Oil Company for their permission to publish this paper, the author records his sincere thanks.

STRATIGRAPHY

With the exception of the inlier on the Bakrala Ridge, which is the most northerly of the topographical and structural digitations into which the Salt Range merges at its eastern end (see fig. 2), the areas described are a part of the almost continuous exposures of the Eocene succession along the Salt Range Plateau. Detailed examination, measurement, and bed-by-bed sampling of the formations was carried out at intervals of several miles along the outcrop, and the detailed sections connected by strike traverses. Five sections, at points indicated on figure 2, and localized in the Geographical Index (p. 834) are chosen to illustrate in adequate detail the vertical and lateral distribution of lithologies and faunas.

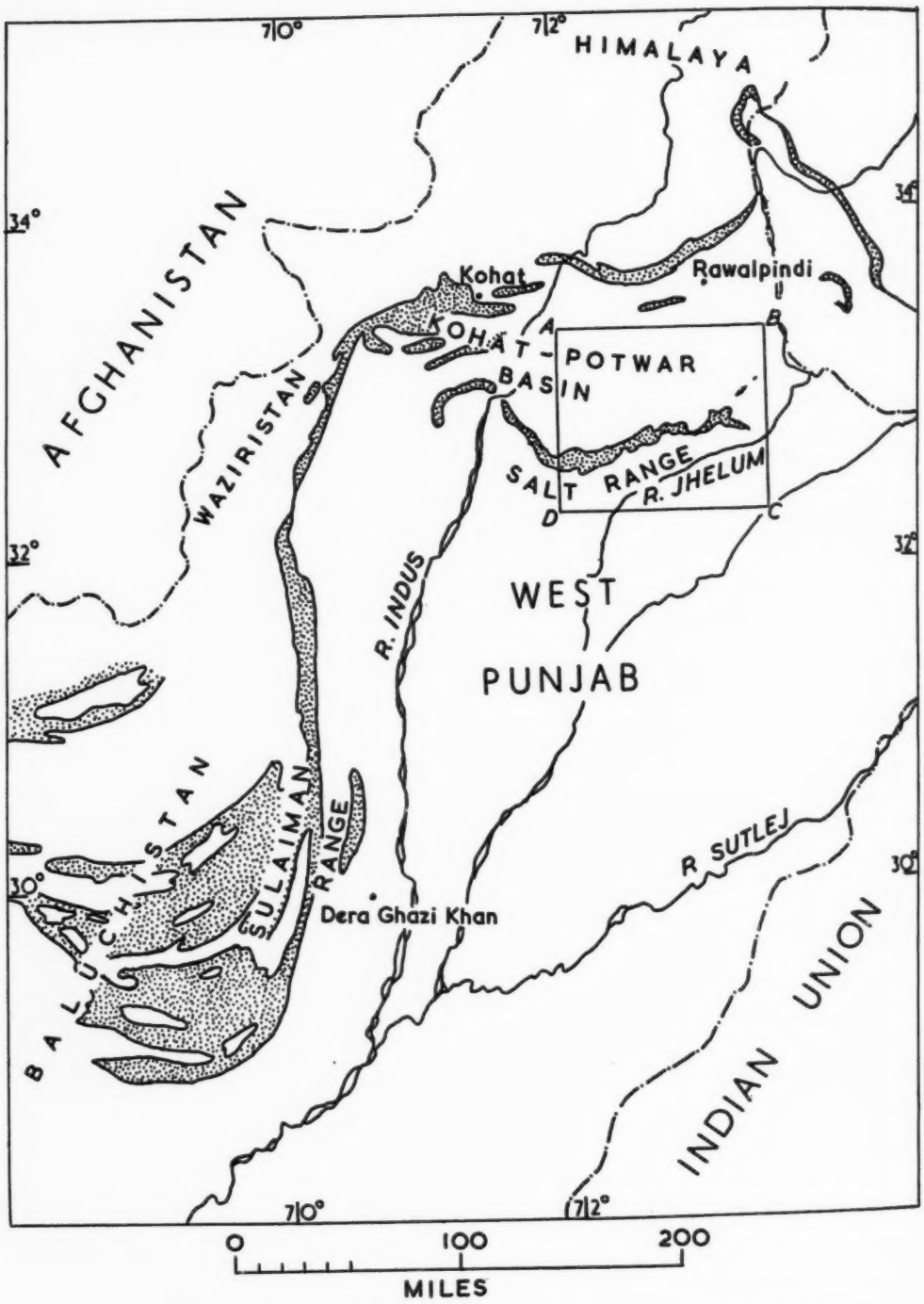


FIG. *1*—The Eocene outcrops of part of the Indus valley system, western Pakistan.

DESCRIPTION OF SECTIONS

From east to west across the area, the development of the Bhadrar beds is described as follows.

Sections southwest of Tarki (Bakrala Ridge).—One mile southwest of the Tarki railway station, the end of the Bakrala Ridge inlier of Eocene and older rocks is well exposed in a stream section and nearby quarry workings. The structure is complicated by small-scale faulting, but the following succession can be worked out.

	BASAL MURREE UNCONFORMITY	Thickness in feet
UPPER BHADRAR	White, bedded, porcellanous limestone with thinner beds of rubbly white limestone and calcareous shale. Several bands with numerous *Orbitolites complanatus.*	35
LOWER BHADRAR	Purplish and red shales with thin bands of calcareous shale, one of which contains *Assilina daviesi* and squashed shells.	25
	Soft, fine, purple and grey shales with harder calcareous bands containing *Assilina daviesi, Assilina granulosa* var. *chhumbiensis,* and squashed molluscan shells.	45

The base of the lower Bhadrar shales is not seen in these sections, but two miles further west, recent quarrying operations have opened up excellent exposures of the succession. The lower Bhadrar shales are crushed in a strike fault structure, and only half of their thickness is visible, but the shales are clearly seen to be underlain by about 15 feet of marl containing many Foraminifera, including *Assilina granulosa* var. *chhumbiensis, Nummulites* aff. *N. atacicus, Lockhartia* spp., and *Rotalia trochidiformis.*

The foraminiferal marls rest, without evidence of unconformity, on the hard, grey, nodular Sakesar limestone, about 50 feet of which is exposed in these sections. The following Foraminifera were collected from the limestone: *Alveolina ovoidea, Assilina granulosa, A. granulosa* var., *Nummulites* aff. *N. atacicus, Rotalia trochidiformis.*

Sections north of Choa Saidan Shah.—From the road from Chakwal to Choa Saidan Shah, a broad anticline in Eocene rocks is seen west of Chhumbi village. Around the fringe of the anticline the uppermost Eocene beds are well exposed in several stream sections. On the north flank, near Khajurla village, the basal Murree bed is often a coarse conglomerate containing cobbles of Sakesar limestone and, in one locality, a six inch band of rolled chert nodules, also probably derived from the Sakesar limestone. In other localities the basal Murree bed is a pseudo-conglomerate with derived Foraminifera. The following section (*shown at the top of the next page*) in the Bhadrar beds was measured one mile north of Choa Saidan Shah.

Outliers of the Bhadrar beds cover large areas of the plateau northwest and west of Choa Saidan Shah. In the northern and western parts the porcellanous limestones of the upper Bhadrar attain a maximum thickness of 45 feet, the average being about 25 feet. At several localities, shaly partings about 20–25 feet from the base contain abundant *Orbitolites complanatus, Opertorbitolites* sp., and *Miliolidae.* Chert strings and nodules are common in the uppermost 20 feet, but the only fossils seen are stunted specimens of *Lockhartia tipperi, Rotalia trochidiformis,* and *Nummulites* sp.

To the south, the upper Bhadrar is progressively overstepped at the basal Murree unconformity. About one mile along the road leading south from Choa Saidan Shah, the basal Murree conglomerate rests directly on the lower Bhadrar.

During the examination of the northerly exposures of the lower Bhadrar, numerous fragmentary shells and echinoderms were collected, but it was not until the southern areas of the plateau were examined at a later date that well-preserved specimens were found in large numbers. The fauna listed

	Basal Murree Unconformity	Thickness in feet
UPPER BHADRAR	Dense, light grey, porcellanous limestone, thick bedded and sutured, with shaly partings.	5
	Fine shale with limestone nodules.	1
	Porcellanous, sutured limestone with nodular layer at top.	6
LOWER BHADRAR[1]	Fine, greenish and buff or yellowish shales with thin beds of nodular marl and one band of limestone. Several highly foraminiferal bands with: *Assilina daviesi, A. granulosa* var. *chhumbiensis, Nummulites* aff. *N. atacicus.*	45
	Nodular limestone with marly bands. Fauna: *Assilina daviesi, A. spinosa, Nummulites* aff. *N. atacicus.*	4
SAKESAR LIMESTONE	Massive grey limestone with *Alveolina ovoidea, Assilina granulosa,* etc.	

[1] The colors of the lower Bhadrar outcrops are due to limonite staining. When unweathered, as in the oil field cores, the beds are greenish grey with abundant pyrites.

below was collected from two outliers about one mile south and southwest of Dalwal. A number of specimens were collected "in situ" from two calcareous nodular bands in the upper part of the lower Bhadrar, but the majority of the specimens were found on the lower scree slopes of the lower Bhadrar and on the dip slope of the Sakesar limestone.

Fauna:

Echinoderms: *Conoclypeus pilgrimi* Davies
Conoclypeus pinfoldi Gill, n. sp.

The following mollusks have been identified by Dr. F. E. Eames. Dr. Eames also gives the stratigraphical range of these forms in the Indian Eocene, based on published information:

Campanile giganteum (Lamarck)	Lower Shekhan limestone and Kirthar
Euspirocrommium oweni (d'Archiac and Haime)	Ranikot to Miocene
Gosavia humberti (d'Archiac and Haime)	Ranikot to Kirthar
Hippochrenes amplus (Solander)	Ranikot to Kirthar
Velates perversus (Gmelin)	Ranikot to Kirthar to upper Eocene
Vicetia vredenburgi (Schilder)	*Alveolina* limestone (Laki)
Blagraveia sindensis (d'Archiac and Haime)	Laki to Kirthar
Chama brimonti (d'Archiac and Haime)	Laki
Discors sp. A (new to India)	
Euphenax coxi (Vokes)	Sabathu beds (probably lower Kirthar)
Trachycardium cotteri (Cox)	Laki to Kirthar
Deltoidonautilus sp. A (probably *D. major* of Carter)	*?Alveolina* limestone (Laki)
Nautilus labechei (d'Archiac and Haime)	*Cardita beaumonti* beds to Laki

Dr. Eames comments as follows: "The fauna seems undoubtedly to be of Upper Laki age, which apparently agrees with your own views as to the age of the Lower Bhadrar beds. The most interesting feature is the occurrence of *Euphenax coxi* which had not previously been recorded below the Sabathu beds (probably Lower Kirthar)."

Sections near Nurpur.—At the eastern end of the Dalwal Plateau, near Kallar Kahar, there is a new feature in the lower Bhadrar beds in the development of a hard bed of limestone, about 5 feet thick, occurring about a third of the distance from the top of the lower Bhadrar. This bed can be followed westward in almost continuous exposures, and is seen to thicken in this direction, until at Nurpur it is about 20 feet thick. The section on page 829 was measured about a quarter of a mile northeast of the Civil Rest House, Nurpur (Sethi).

		Thickness in feet
UPPER BHADRAR	Porcellanous, white or cream-colored limestone with *Lockhartia* spp. and *Rotalia trochidiformis*.	10
	White, porcellanous, sutured limestone.	4
LOWER BHADRAR	Buff shales with marly limestone bands. *Assilina daviesi* occurs in a thin bed about 4 feet from the base, together with *Nummulites* aff. *N. atacicus* and *Lockhartia* spp.	10
	Porcellanous limestone in beds 2 to 3 feet thick, with intercalated beds of softer, nodular limestone. Foraminifera: *Alveolina ovoidea*, *Nummulites* aff. *N. atacicus*, *Nummulites* aff. *N. subatacicus*, *Orbitolites complanatus*, *Lockhartia tipperi*.	19
	Greenish or buff shales with marl and marly limestone bands: *Assilina daviesi* occurs abundantly over a range of 5 feet in the middle, together with *Nummulites* aff. *N. atacicus*, *Nummulites* cf. *N. mamilla*, *Lockhartia* spp.	20
SAKESAR LIMESTONE	Grey, nodular limestone.	20+

In the Nurpur area the top of the Sakesar limestone is rubbly and seems to have been reworked, suggesting a disconformity.

The southerly overstep by the basal Murree conglomerate is well marked in this area; in the north, near Vasnal, there are 25–30 feet of upper Bhadrar beds; in the measured section near the Rest House, they are reduced to 14 feet; at the head of the Nilawahan, there are only a few feet; and further to the southeast, south of Bhalial village, the Murree rests directly on the lower Bhadrar, only 10 feet of which is seen in most sections.

Sections near Bhadrar.—A few miles to the west of Nurpur, there are fairly good exposures of the Bhadrar beds in the road cuttings descending from Monhara. Here the succession is almost identical with that at Nurpur. Further west, the exposures at Bhadrar village are unsatisfactory for detailed measurement because of the compressed structure. West of Pail, however, where the kutcha road to Jaba leaves the metalled road, there is a fault scarp forming a low ridge running northwest, along which the Bhadrar beds can be followed in almost continuous exposures for 2 miles. At the southeastern end of the ridge, the section is as shown at the top of page 830.

To the northwest, the lower shaly group becomes progressively more calcareous and the limestone bed above presents a more massive appearance until, immediately west of Pirah village, we have the section shown at the bottom of page 830.

Sections near Kahbakki (west of Jhunga).—For many miles west of the Pail area, no completely exposed section of the Bhadrar beds has been found in the northern part of the Salt Range. The next exposures are at the eastern end of the Khabakki anticline. The stream section shown at the top of page 831 was measured about one mile west of Jhunga village.

Three miles west of the above section, at the head of the Dom Nulla, the upper Bhadrar beds rest on highly fossiliferous, massive and nodular limestones, in which it has not been possible to separate by lithology or fauna, a lower Bhadrar stage from the Sakesar limestone.

Many sections have been examined from the Khabakki area westward to the Indus River, but, while beds occur, which on lithological grounds are correlated with the upper Bhadrar, no beds have been found identifiable with the lower Bhadrar.

SUMMARY OF STRATIGRAPHY

The sections described in detail in the preceding section are shown in columnar form on figure 3, accompanied by the range charts of the Foraminifera. The sharp dis-

		Thickness in feet
UPPER BHADRAR	Platy, porcellanous limestone with chert nodules.	5
LOWER BHADRAR	Shaly marl.	3
	Lumpy (macro-nodular) white limestone with marly, nodular bed 5–8 feet from the top.	23
	Grey green shales and marls with *Nummulites* aff. *N. atacicus*.	6
	Marly limestone.	4
	Marl and shale.	2
	Harder limestone band with *Assilina daviesi*, *Alveolina* spp. etc.	3
	Shales and marls.	4

tinction between the upper and the lower Bhadrar is immediately apparent. Mostly unfossiliferous, the upper Bhadrar porcellanous limestones of the eastern exposures, with an increasing element of argillaceous, dolomitic limestones in the west, were probably deposited in lagoons. Whether the lagoon was saline or brackish is not clear, although the occurrence of anhydrite at this horizon elsewhere in the Kohat-Potwar basin clearly suggests a desiccation phase.

In contrast, the lower Bhadrar beds are clearly a marine deposit. Their most important and striking feature is the development of a calcareous facies from east to west. On the Bakrala Ridge, the argillaceous facies has its greatest development, there being only thin bands of calcareous shale.

The specimens of *Assilina daviesi* from most of these bands are predominantly thin and stunted, probably due to the lack of carbonate (see pp. 837–839).

In the Choa Saidan Shah area, 38 miles to the southwest, all the shales are more calcareous and there are several bands of marl with limestone nodules. The Foraminifera, richer in numbers and in species than at Tarki on the Bakarla Ridge, are no longer stunted. *Assilina daviesi* still predominates and is distributed in several beds over the entire thickness of the lower Bhadrar. *Assilina granulosa* var. *chhumbiensis*, n. var., is common in the lower beds. The habitat also favoured a varied fauna of mollusks

		Thickness in feet
UPPER BHADRAR	Flaggy, porcellanous, grey and white limestone with abundant chert nodules in the middle 3 feet.	10
LOWER BHADRAR	Calcareous shales with *Nummulites* aff. *N. atacicus*, *Alveolina ovoidea* and *Lockhartia* spp.	4
	Homogeneous, lumpy to massive limestone with *Alveolina* spp., *Nummulites* aff. *N. atacicus* and *Orbitolites complanatus*.	26
	Shales and marls. Two limestone beds about 3 feet thick. Bed with *Assilina daviesi* 2 to 4 feet from the base. Other beds with *Alveolina* spp., *Nummulites* aff. *N. atacicus*, *Nummulites* cf. *N. mamilla*, *Orbitolites complanatus*, *Lockhartia* spp., and *Rotalia trochidiformis*.	14
SAKESAR LIMESTONE	Grey, nodular limestone.	

		Thickness in feet
UPPER BHADRAR	Rubbly, porcellanous limestone.	3
	White, calcareous sand.	6
	Dull grey, argillaceous limestone.	5
LOWER BHADRAR	Calcareous shale with *Coskinolina* sp. *Lituonella douvillei*, *Lockhartia* spp., and *Rotalia trochidiformis*.	1
	Porcellanous, lumpy limestone with *Orbitolites complanatus*.	10
	Nodular marl with *Alveolina ovoidea*, *Lockhartia* spp., *Nummulites* aff. *N. atacicus*, *Nummulites* cf. *N. mamilla*, and *Orbitolites complanatus*.	3
	Porcellanous limestone with abundant *Alveolina* spp.	2½
	Marl.	1½
	Porcellanous limestone beds with nodular, marly partings containing abundant *Alveolina* spp., and *Lockhartia* spp.	8
	Bedded, porcellanous limestone with *Assilina granulosa*, *A. leymeriei*, *Lockhartia tipperi*, *Nummulites* aff. *N. atacicus*, and *Nummulites* cf. *N. mamilla*.	10
SAKESAR LIMESTONE	Nodular limestone with chert nodules weathering in beds about 5 feet thick	60+

and echinoderms. Unfortunately, the author was not able to collect sufficiently well-preserved specimens of the thin-shelled mollusks at Tarki, but if this could be done, a comparison of the Tarki and Dalwal macro-fauna might show morphological differences similar to those shown by the Foraminifera.

The westerly increase of calcareous rocks in the lower Bhadrar continues west of Choa Saidan Shah until at Kallar Kahar a bed of porcellanous limestone appears. This limestone thickens at the expense of underlying and overlying shales (the total thickness of the lower Bhadrar remaining fairly constant throughout this area), until at Nurpur it is 19 feet thick. In this section *Assilina daviesi* has a more restricted range than at Choa Saidan Shah, but it is found in both the upper and the lower shale bands. *Assilina granulosa* var. *chhumbiensis*, n. var., has not been found in this section or in any other to the west of this point. The most abundant Foraminifera are *Nummulites* aff. *N. atacicus* and *Nummulites* cf. *N. mamilla*.

Near Pail, 9 miles still farther west, the 19 foot limestone of Nurpur has increased to 26 feet in thickness, the upper shaly bed being only a few feet thick, and the lower bed being reduced to 14 feet, about half of which is composed of thin beds of limestone and marl. In this section *Assilina daviesi* has disappeared from the upper shale band and has a restricted range of 4 feet at the base of the lower shale. The accompanying foraminiferal fauna is indistinguishable from that of the underlying Sakesar limestone.

In the Jhunga section, 7 miles farther west, there are beds of porcellanous limestone and calcareous shale similar in lithology to the lower Bhadrar beds near Pail, but the facies and fauna which typify the lower Bhadrar in the eastern parts of the Salt Range have disappeared. Apart from the *Dictyoconus* group forms in the top foot, the fauna is indistinguishable from that of the underlying Sakesar limestone. *Assilina daviesi* has not been found in this section, nor has it appeared from any other locality in the upper Laki to the west of this point. The genus *Assilina* is represented by typical *A. granulosa*, *A. leymeriei*, and *A. subspinosa*.

The conclusion of the foregoing analysis is that the lower Bhadrar shales, which form

such a distinct lithological and faunal unit in the eastern Salt Range are homotaxial with beds in the west that would be mapped as the uppermost layers of the Sakesar limestone, though the occurrence of *Dictyoconus* group forms and the abundance of *Orbitolites complanatus* may allow the limestone facies of the lower Bhadar to be differentiated. The easterly development of shale facies probably relates to an approach to the edge of the basin of deposition with shallower water and more land-derived detritus. The rubbly and red-stained top of the Sakesar limestone in some localities suggests a disconformity, but there is no evidence of overlap at the base of the lower Bhadrar, and the greater thickness of this formation in the eastern sections is due to a greater rate of deposition, the thickening being distributed over the entire range.

FAUNAL ANALYSIS

The foraminiferal faunas can be divided into three distinct groups from a consideration of the effect of the facies change on their morphology and distribution:

(a) A group, including the genera *Nummulites*, *Lockhartia* and *Rotalia*, which does not appear to be significantly affected either in morphology or population densities by the passage from shale to limestone.

(b) The species *Assilina granulosa* shows pronounced morphological differences in limestone and shale facies. It is present in type form in the limestone areas, but in the main outcrop of the lower Bhadrar shales is represented by the distinct morphological variant —the variety *chhumbiensis*. Only in the highly foraminiferal marls at the base of the lower Bhadrar at Tarki is there any gradation in one community from the type form to the variety. The similarity of *A. granulosa* var. *chhumbiensis* to *A. exponens* of the succeeding Kirthar series (middle Eocene) is so strong that one is tempted to suggest a phylogenetic relationship. If this relationship is accepted, *A. granulosa* var. *chhumbiensis* is clearly a mutation deserving specific recognition, and would constitute an example of local evolution under special ecological circumstances. Such an interpretation, however, is highly speculative, and the author prefers to indicate the morphological change at the level of a variety.

(c) The third group is that which gives the fauna of the limestone or shale facies a distinctive character, being highly selective with respect to environment. *Assilina daviesi* is, to an extraordinary degree, restricted both geographically and chronologically to shale facies. The genus *Dictyoconus*, and to a lesser extent the porcellanous *Alveolina* and *Orbitolites*, characterize the clearer-water, limestone facies.

The manner in which *Assilina*

EXPLANATION OF PLATE 88

FIGS. *1–4*—*Nummulites* aff. *N. atacicus* Leymerie. From Laki shales north of Mahura, Kala Chitta Range, showing polar pustule in young and some intermediate forms. ×65. P.41510–P.41513. (p. 836)

5—*Nummulites* aff. *N. atacicus* Leymerie. From the lower Bhadrar beds, Nurpur. Median section showing typical buried polar pustule in adult. ×9.2. P.41514. (p. 836)

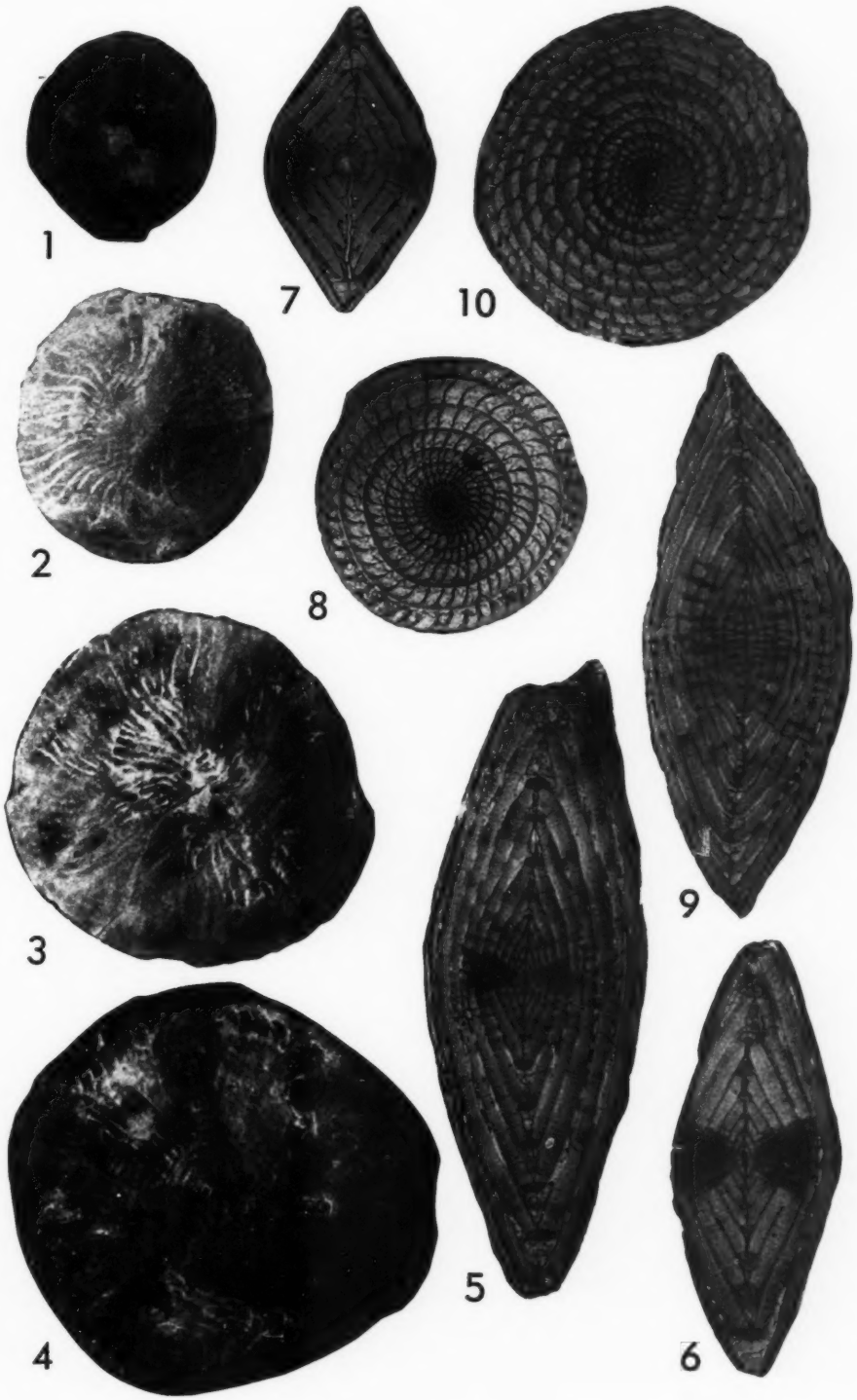
6—*Nummulites* aff. *N. atacicus* Leymerie. From the Sakesar limestone, Kallar Kahar. Median section showing polar pustule appearing at the surface of a young specimen. ×9. P.41515. (p. 836)

7—*Nummulites* cf. *N. mamilla* (Fichtel and Moll). From the lower Bhadrar beds, Dalwal. Median section. ×14. P.41516. (p. 837)

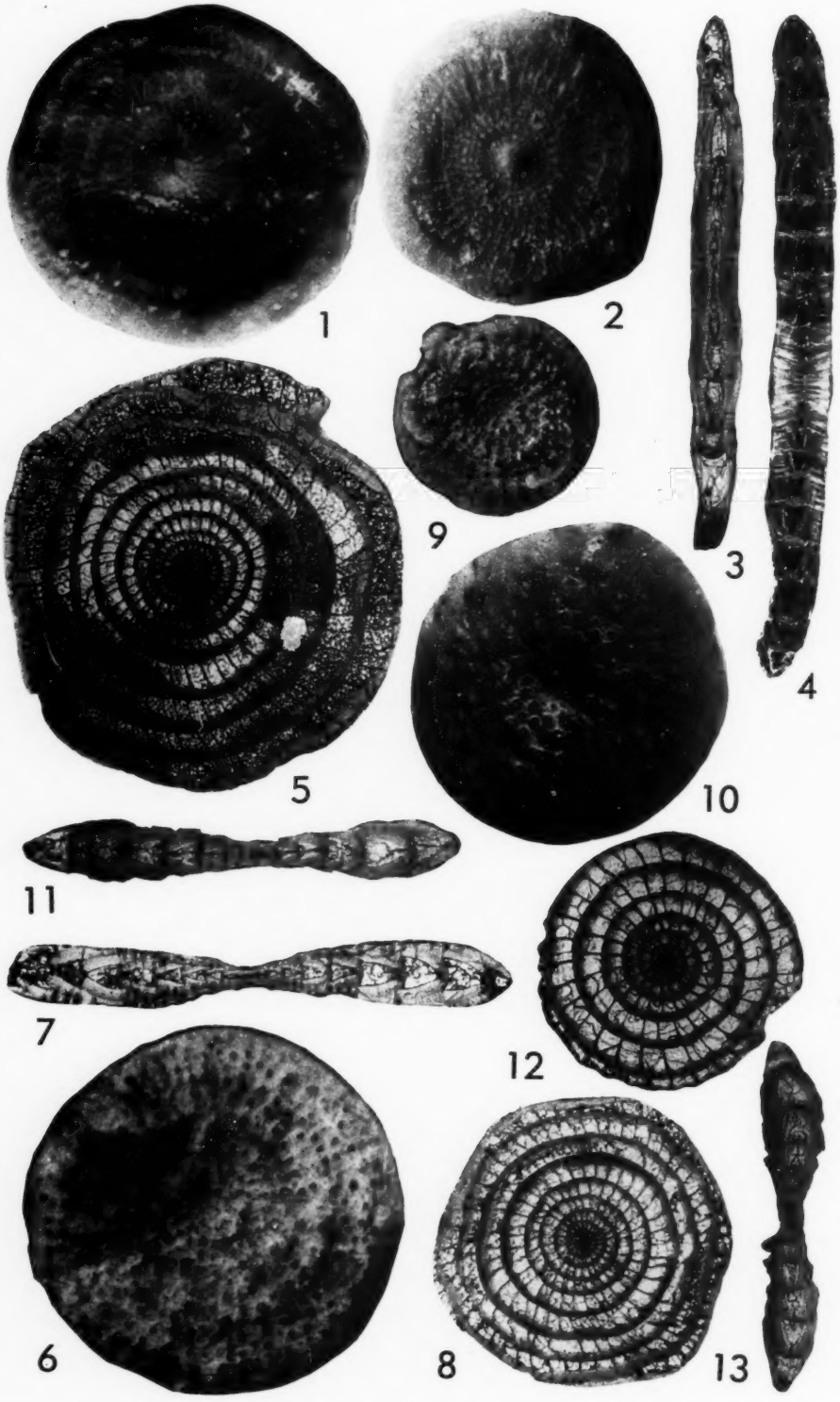
8—*Nummulites* aff. *N. atacicus* Leymerie. From the lower Bhadrar beds, Nurpur. Equatorial section illustrating typical spire and septa of Laki form. ×5.3. P.41517. (p. 836)

9—*?Nummulites atacicus* Leymerie. From the Nummulite shale (Kirthar), near Mahura, Kala Chitta Range. Median section of Kirthar form for comparison with figs. *5* and *6*. ×8.6. P.41518. (p. 836)

10—*?Nummulites atacicus* Leymerie. From the Nummulite shale, Mahura, Kala Chitta Range. Equatorial section for comparison with Laki form (fig. *8*). ×4.7. P.41519. (p. 836)



Gill, Eocene fauna from the Punjab Salt Range, Pakistan



Gill, Eocene fauna from the Punjab Salt Range, Pakistan

daviesi disappears from the Bhadrar beds at the level of the thick limestone in the middle of this formation, then reappears in great numbers when shale conditions again spread far to the west, suggests that the communities of *A. daviesi* were capable of extensive and relatively rapid migration towards areas of more favourable ecology. It is impossible to suggest which aspect of the environment was the dominant factor, for it is apparent from the stunted forms at Tarki that *A. daviesi* possessed its own fairly wide limits of toleration with respect to environment in some respects, with consequent morphological variations.

However imperfect our understanding of foraminiferal paleo-ecology, the above analysis shows that an empirical relationship of fauna to facies may be established. This relationship has an important bearing on the establishing of any scheme of zoning. Local faunal zones may be of very little value for long distance correlation where facies exercise such extensive control on the distribution of the various faunal elements.

In his scheme of correlation of the Laki beds of the Kohat-Potwar basin, Davies (1940, 1941, 1943) has placed great emphasis on the local characteristics of the fauna. He maintains that the Shekhan limestone of Kohat District is younger than any marine Laki formation on the Salt Range because the Kohat formation has an abundance of *Dictyoconus* group forms and *Assilina daviesi*, together with a variety of echinoids. The Bhadrar beds, which he incorrectly describes as "fragmentary outliers" (1943, p. 64), are stated to be "definitely younger than the Sakesar limestone and older than the Shekhan limestone" (1941, p. 150). The evidence given in the present paper, together with that of oil field boreholes on the Potwar Plateau, clearly supports the conclusion of Pinfold (1940), based on comparative stratigraphy, that the highest marine Laki beds of the Kohat-Potwar basin are everywhere homotaxial, but that they differ in facies and in faunal phase.

Although subject to vagaries of geographical distribution due to change of facies, the following faunal elements of the Bhadrar beds appear on present evidence to be characteristic of the upper part of the marine Laki.

Dictyoconus group forms do not appear in deposits laid down before the highest marine Laki beds of limestone facies. In the Potwar oil fields they are restricted to a bed of lime-

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EXPLANATION OF PLATE 89

FIG. *1*—*Assilina granulosa* var. *chhumbiensis* Gill, n. var. From the lower Bhadrar beds, Choa Saidan Shah. ×3.5. P.41520. (p. 839)

2—*Assilina granulosa* var. *chhumbiensis* Gill, n. var. From the lower Bhadrar beds, Dalwal. ×3.2. P.41507. (p. 839)

3—*Assilina granulosa* (d'Archiac). From the Sakesar limestone, Jaba. ×8. P.41494. (p. 839)

4—*Assilina granulosa* var. *chhumbiensis* Gill, n. var. From the lower Bhadrar beds, Choa Saidan Shah. Median section. ×7.5. P.41521. (p. 839)

5—*Assilina granulosa* var. *chhumbiensis* Gill, n. var. From the lower Bhadrar beds, Choa Saidan Shah. Equatorial section. ×5. P.41522. (p. 839)

6—*Assilina daviesi* de Cizancourt. From the lower Bhadrar beds, Choa Saidan Shah. ×8. P.41523. (p. 837)

7—*Assilina daviesi* de Cizancourt. From the lower Bhadrar beds, Nurpur (Salt Range). Median section of type form. ×8. P.41524. (p. 837)

8—*Assilina daviesi* de Cizancourt. From the lower Bhadrar beds, Choa Saidan Shah (Salt Range). Equatorial section of type form. ×5. P.41525. (p. 837)

9—*Assilina daviesi* de Cizancourt. From the lower Bhadrar beds, Tarki (Bakrala Ridge). Stunted and heavily granulated form from higher levels. ×8. P.41526. (p. 837)

10—*Assilina daviesi* de Cizancourt. From the lower Bhadrar beds, Tarki. Form common in lowest bed. ×8. P.41527. (p. 837)

11—Median section of form similar to fig. *10*. ×15. P.41528. (p. 837)

12—*Assilina daviesi* de Cizancourt. From the lower Bhadrar beds, Tarki. Equatorial Section. ×10. P.41529. (p. 837)

13—Median section of form similar to fig. *9*. ×11. P.41530. (p. 837)

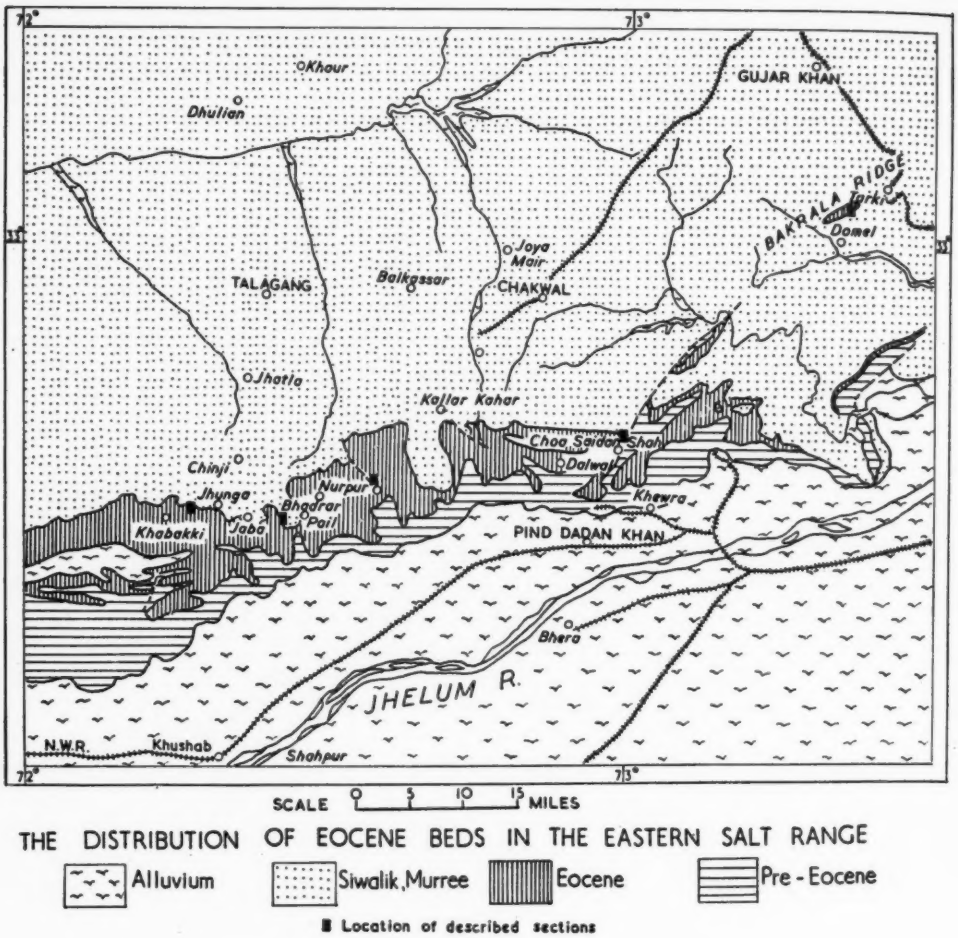

FIG. 2

GEOGRAPHICAL INDEX

		Survey of India 1" Map Sheet
Balkassar oil field	32° 58′ :72° 40′	43 D/9
Bhadrar	32° 39′ :72° 29½′	43 D/6
Choa Saidan Shah	32° 43½′:72° 59′	43 D/14
Dalwal	32° 42½′:72° 53½′	43 D/14
Dhulian oil field	33° 12′ :72° 20′	43 C/8
Jaba	32° 52′ :71° 41′	38 P/9
Jhunga	32° 37′ :72° 20′	43 D/6
Joya Mair oil field	32° 59′ :72° 50′	43 D/13
Kallar Kahar	32° 47′ :72° 42′	43 D/9
Khabakki	32° 37′ :72° 14′	43 D/2
Khairabad	32° 53′ :71° 36′	38 P/9
Kohat	33° 36′ :71° 29′	38 O/6
Nurpur	32° 40′ :72° 35′	43 D/10
Pail	32° 38′ :72° 28′	43 D/6
Panoba	33° 36½′:71° 54′	38 O/14
Potwar	33° 0′ :72° 0′	
Salt Range	32° 30′ :72° 0′	
Tarki	33° 04′ :73° 25½′	43 G/8
Vasnal	32° 42½′:72° 33′	43 D/10

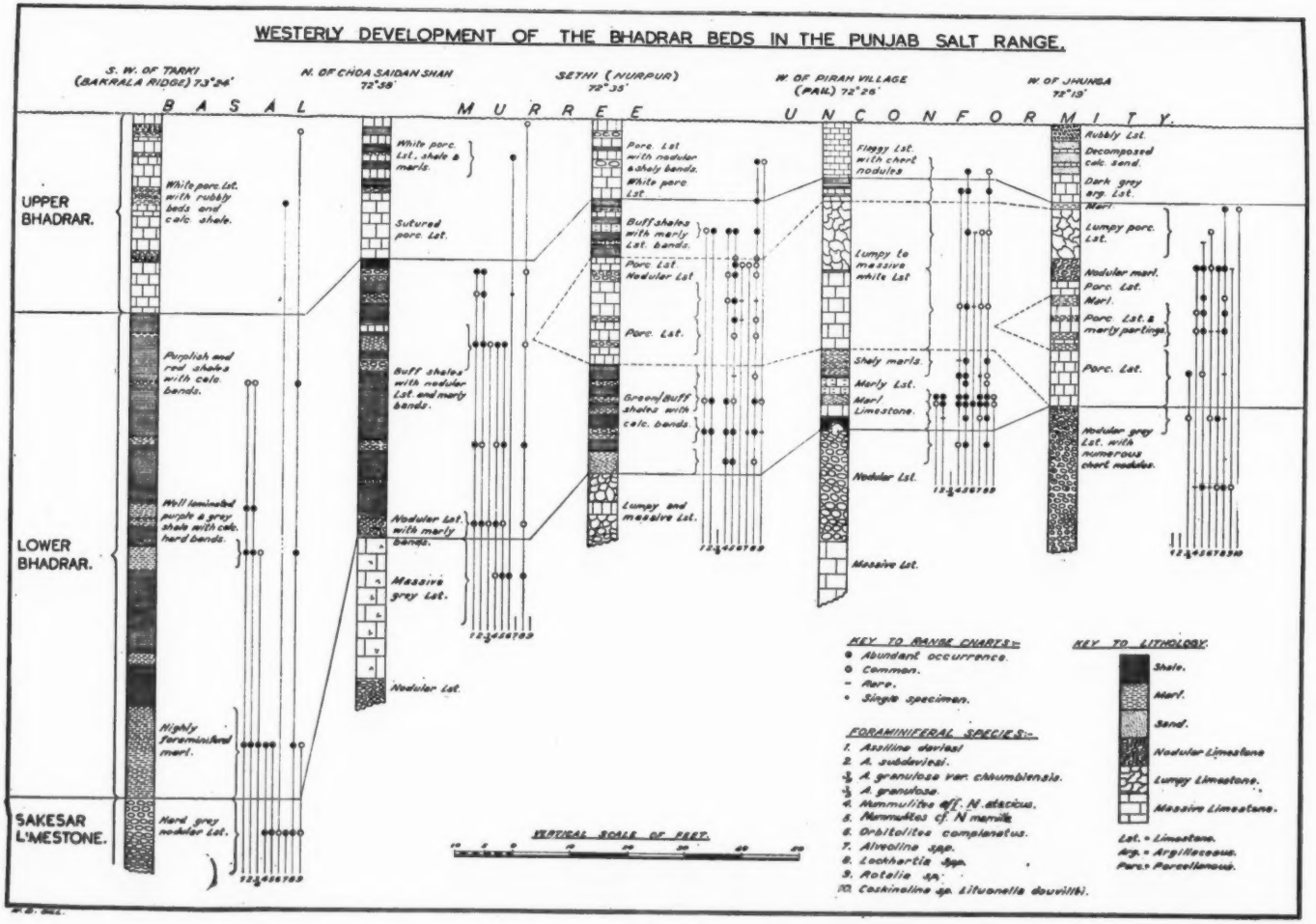
WESTERLY DEVELOPMENT OF THE BHADRAR BEDS IN THE PUNJAB SALT RANGE.
S. W. OF TARKI (BARRALA RIDGE) 73°24'
N. OF CHOA SAIDAN SHAH 72°58'
SETHI (NURPUR) 72°35'
W. OF PIRAN VILLAGE (PAIL) 72°26'
W. OF JHUNGA 72°13'
BASAL MURREE UNCONFORMITY.
UPPER BHADRAR.
LOWER BHADRAR.
SAKESAR L'MESTONE.
White porc. Lst. with rubbly beds and calc. shale.
Purplish and red shales with calc. bands.
Well laminated purple & grey shale with calc. hard bands.
Highly foraminiferal marl.
Hard grey nodular Lst.
White porc. Lst., shale & marls.
Sutured porc. Lst.
Buff shales with nodular Lst. and marly bands.
Nodular Lst. with marly bands.
Massive grey Lst.
Nodular Lst.
Porc. Lst with nodular & shaly bands.
White porc. Lst.
Buff shales with marly Lst. bands.
Porc. Lst.
Nodular Lst
Porc. Lst.
Green/Buff shales with calc. bands.
Lumpy and massive Lst.
Flinty Lst. with chert nodules
Lumpy to massive white Lst
Shaly marls.
Marly Lst.
Marl Limestone.
Nodular Lst.
Massive Lst.
Rubbly Lst.
Decomposed calc. sand.
Dark grey arg. Lst.
Marl
Lumpy porc. Lst.
Nodular marl.
Porc. Lst.
Marl.
Porc. Lst. & marly partings
Porc. Lst.
Nodular grey Lst. with numerous chert nodules.
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9 10
VERTICAL SCALE OF FEET.
KEY TO RANGE CHARTS:-
Abundant occurrence.
Common.
Rare.
Single specimen.
FORAMINIFERAL SPECIES:-
1. Assilina davisi
2. A. subdavisi.
3. A. granulosa var. chaumbiensis.
4. A. granulosa.
5. Nummulites aff. N. atacicus.
6. Nummulites cf. N. murrie.
7. Orbitolites complanatus.
8. Alveolina spp.
9. Lockhartia spp.
10. Coskinolina sp. Lituonella douvillei.
KEY TO LITHOLOGY:
Shale.
Marl.
Sand.
Nodular Limestone.
Lumpy Limestone.
Massive Limestone.
Lst. = Limestone.
Arg. = Argillaceous.
Porc. = Porcellaneous.

FIG. 3

stone some 10–15 feet thick. The group occurs abundantly in the succeeding Kirthar (middle Eocene) formations.

The abundance of *Orbitolites complanatus* in the limestone facies of the lower Bhadrar and throughout the upper Bhadrar would also seem, on existing evidence, to indicate an upper Laki age, for although this species occurs sporadically in lower Laki formations (for example in the Sakesar limestone) it has not appeared abundantly in the author's collections from the Kohat-Potwar basin, from other than high levels in the Laki, or from the succeeding Kirthar.

Assilina granulosa var. *chhumbiensis* is a local zone index of the lower Bhadrar beds of shale facies, but it has not so far been recorded from other areas in the basin. Although a trend towards *A. exponens* of the Kirthar would suggest a late Laki age, it may be only a local morphological variety or "race."

Although restricted in its distribution to shale facies, the type form of *Assilina daviesi* appears to be restricted to the upper part of the Laki. There is, however, a morphological gradation from an earlier form which occurs in the lower Laki. In the Salt Range, the average specimen from the Nammal shales is distinct from that of the Bhadrar beds, but in Kohat District, where the vertical range of the species in shale facies is much greater, the type form extends much lower into the marine Laki. Davies (1940, etc.) was unaware of the occurrence in the Nammal shales which makes his correlation of the Bhadrar beds with the Ghazij shale of Baluchistan very doubtful.

The main object of this paper is not, however, to discuss the many disagreements which have arisen as to the regional correlation of Eocene beds in western Pakistan, but to place on record a clear example of the complexities introduced into bio-stratigraphy by changes in facies. In the author's opinion these complexities offer a convincing explanation of the many anomalies which have arisen from previous attempts to apply local faunal zones to long distance correlation. Further detailed studies of Eocene faunas on the lines of the present investigation must be undertaken, however, before any systematic regional correlation can be attempted.

SYSTEMATIC PALEONTOLOGY

Class SARCODINA
Order FORAMINIFERA
Family NUMMULITIDAE
Genus NUMMULITES Lamarck, 1801
NUMMULITES aff. N. ATACICUS Leymerie
Plate 88, figures 1–6, 8

Nuttall and Davies ascribe to *N. atacicus* a range from Laki to Kirthar reporting no differences in the forms found at any horizon. There is, indeed, little difference in external appearance, except for a tendency for the Kirthar form to have more whirling septal filaments, but important differences in internal structure, of specific order, have been detected. The present observations are based on 33 median sections and 22 equatorial sections of specimens collected from the entire range of Laki and Kirthar beds at 16 localities, supplemented by many thin sections of specimens in cores of Laki beds from deep wells in the Potwar oil fields.

In equatorial section, the Laki form is distinctly more loosely coiled, although there is gradation to a more closely coiled form in the upper Laki. Typical sections of Laki and Kirthar forms can be compared from figures 8 and 10 on plate 88. The difference in coiling is also illustrated by the graphed measurements of four typical equatorial sections of each form in figure 4.

This shows the Laki form to have a greater rate of opening of the spire, discernible from whorl 6. The form of the septa is also distinct. In the Laki form the septa are curved throughout the spire, whereas those of the Kirthar form are often straight, particularly in the later whorls, and exhibit a much more pronounced forward inclination. Another point of difference is the greater number of septa in the Laki form, the average specimen having 9–10 septa in $\frac{1}{4}$ of whorl 8, compared with 7–8 for the same whorl in the Kirthar forms.

A further important distinction is seen in median sections. Some 90% of the Laki specimens show a polar pustule, buried in adults (pl. 88, figs. 4 and 5), and often exposed at the surface in younger specimens (pl. 88, figs. 2, 3 and 6). Ten percent of the specimens show a group of polar pillars, but no specimen in the collection shows the widely scattered pillars characteristic of the Kirthar form (pl. 88, fig. 9), though

Davies figures a median section of this type from the Shekhan limestone (Davies and Pinfold, 1937, pl. 3, fig. 8).

The great variation in the septal filaments of the Laki form, from almost straight and radiate in very young specimens to irregularly sinuate in the adult, has been described

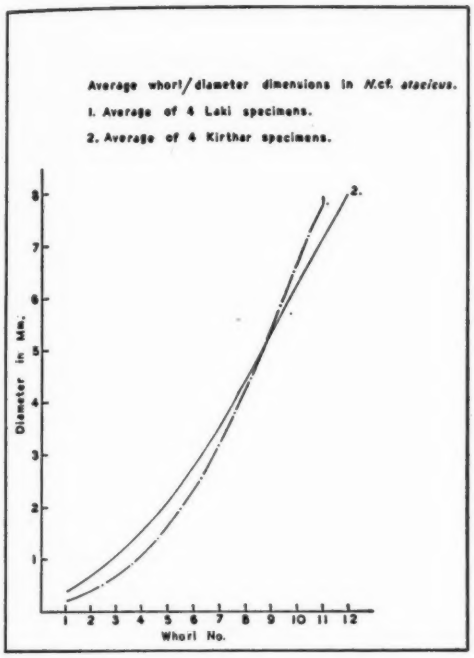

FIG. 4

and figured by Nuttall (1925, pl. 25, figs. 1–6). The external aspect of the Laki form in the Kohat-Potwar basin is illustrated by figures 1–4, plate 88, figures 1 and 3 showing the polar pustule at the surface.

Without reference to the types, it is not certain which of the forms is referable to *N. atacicus* of the European Eocene. Davies, in Davies and Pinfold, (1937, p. 27) states that Douvillé[1] has shown that *N. atacicus* normally possesses a buried polar pustule, which is apt to break up into pillars in an allied form which he calls *N. granifer*. It appears that the Laki form of the Kohat-Potwar basin is correctly identified with the type, and that the Kirthar form is a species belonging to the group *N. perforatus* of Boussac.[2]

[1] Mém. Carte géol. det. France, 1919, p. 55.

NUMMULITES cf. N. MAMILLA
(Fichtel and Moll)
Plate 88, figure 7

Nautilus mamilla FICHTEL and MOLL, 1798, Testacea Microscopica, pp. 53–54, pl. 6, figs. a–d. See DAVIES in Davies and Pinfold, 1937, pp. 22–23, for complete synonymy.

Davies (in Davies and Pinfold, 1937), followed Nuttall (1925) and tentatively included the small megalospheric *Nummulites* with a polar pustule, which occur in large numbers in Laki beds, in the species *N. mamilla*. There is ample support for Nuttall's opinion that it is the megalospheric form of *N. atacicus*. The external aspect differs from that of a very young *N.* aff. *N. atacicus* in being stouter. The equatorial sections show curved septa, similar to those of *N.* aff. *N. atacicus*. The median section shows the stouter shape and large, frequently double, megalosphere.

Genus ASSILINA d'Orbigny, 1826

On the evidence of a monograph-scale study of the representatives of this genus in the Laki of the Kohat-Potwar basin, the diagnostic specific characters, in order of reliability, have been found to be as follows:

(1) Degree of envelopment of the spiral sheet
(2) Rate of opening of the spire
(3) Form of the septa
(4) Type and degree of ornamentation.

ASSILINA DAVIESI de Cizancourt, 1938
Plate 89, figures 6–13

Assilina granulosa (d'Archiac) DAVIES, 1924, Jour. Asiat. Soc. Bengal, (n.s.), vol. 20, p. 213.
Assilina granulosa (d'Archiac) (part); NUTTALL, 1925, Quart. Jour. Geol. Soc. London, vol. 81, pl. 26, fig. 2.
Assilina cf. *A. pustulosa* Doncieux DAVIES, 1937, in Davies and Pinfold, Pal. Ind., n.s., vol. 24, mem. 1, pl. 4, figs. 13–15, 18, 22.
Assilina daviesi DE CIZANCOURT, 1938, Mem. Soc. géol. France, n.s. 17. fasc. 1. mem. 39, pl. 3, fig. 24.

The form from the Dalwal-Nurpur area on the Salt Range has been fully described by Davies (1925, p. 24). The external aspect

[2] Mr. Eames' opinion is that the Kirthar forms figured here (pl. 88, figs. 11 and 13) are a thin-edged variant of *Nummulites obtusus* var. *uranensis* (De la Harpe).

and median section of this form is figured (pl. 89, figs. 6–8) for comparison with the forms from Tarki. This large form, with broad chambers and rounded margin, is the commonest at most localities in the upper Laki of the Kala Chitta Range, and in the Shekhan limestone of Kohat District.

On the Bakrala Ridge, *Assilina daviesi* from the lowest bed of the lower Bhadrar is similar to the general upper Laki form described above, with a tendency to be thinner and more coarsely ornamented (pl. 89, fig. 10). The form from the higher levels of the lower Bhadrar, however, presents a distinctly different appearance (pl. 89, fig. 9). The average diameter is less than 5 mm. and the test proportionately very thin. This stunted aspect would appear to be directly related to the lack of lime, the facies of the lower Bhadrar being here much less calcareous than on the Central Salt Range.

In spite of the otherwise stunted aspect, the form is heavily granulated, almost tuberculated. These pillars of shell substance along the lines of the septa obviously strengthen the test which would otherwise be weakened by the thinness of the walls.

The median section is typically "wasp-waisted" due to the absence of lateral laminae, and provides a simple diagnosis of the species. The equatorial section shows a distinctly more tightly coiled spire than in *Assilina granulosa*, and septa that are straight for seven-eighths of their length with a distinct forward inclination of 20°–30° in the later whorls. The only exceptions in this aspect are from Tarki, where some specimens have curved septa lacking pronounced inclination (see pl. 89, fig. 12).

Distribution.—The manner in which *Assilina daviesi* disappears from the lower Bhadrar beds as the limestone facies develops westward on the Salt Range has been described in the earlier part of this paper. The distribution of the species in these beds does not suggest annihilation at the sudden onset of clearer, possibly deeper water conditions represented by the porcellanous limestone bands, but a complete migration of the living forms to the areas in the east where shale facies conditions existed. When shale facies again spread to the west at the top of the lower Bhadrar, the area was rapidly invaded by *Assilina daviesi* in large numbers. This intimate association of *A. daviesi* with shale facies, calls for caution when considering the zonal value of the species, since its stratigraphical and geographical distribution is probably largely determined by facies. In the western Salt Range, a stouter variety with a deep crater at the poles, grading into almost typical *Assilina daviesi*, occurs in the lower Laki of the Jaba area, but has not been recorded east of this locality. Its absence from the lower Laki of the eastern Salt Range is possibly related to the development of more calcareous facies at this horizon. At the onset of conditions represented by massive Sakesar limestone, *A. daviesi* appears to have migrated from the Salt Range area towards the edges of the basin, to reappear only in the eastern area in the shale facies of the lower Bhadrar.

In Kohat District, on the Tarkhobi-Panoba fold, the Laki is predominantly shaly in facies, and this probably accounts for the greater stratigraphical distribution of *Assilina daviesi* in this area. Dr. Eames has recently found the species at a lower Laki horizon here, and the author's collections show the species to range from a band in the green shales about 35 feet below its base to the top of the Shekhan limestone.

In the western Kala Chitta hills, *Assilina daviesi* seems to be restricted in range to the 80 feet of shales above the massive Laki limestone. At the western end of the Kala Chitta the highest marine Laki beds are of limestone facies, and *A. daviesi* has not been found. It is absent also from the limestone facies of upper Laki in the Khaire Murat Range, the Khaur oil field and the Dhulian oil field.

ASSILINA SUBDAVIESI Gill, n.sp.
Plate 91, figures 5, 6

Assilina subdaviesi DE CIZANCOURT (nomen nudum), 1938, Mém., Soc. géol. France, n.s. 17. mem. 39, p. 23.

Occurring abundantly at all levels with *Assilina daviesi* is the much smaller megalospheric form. In the Bhadrar beds of the central Salt Range, the average diameter is about 2.6 mm., usually with four whorls. It is stout, with a sharp keel and deep, heavily granulated, polar crater. Thinner

forms from Tarki are similar to *A. subspinosa* in external aspect, but the median section shows the absence of the spiral sheet at the poles. The only difference detected between lower Laki and upper Laki specimens is that the former usually have the larger megalosphere.

Holotype.—P 41544.

ASSILINA GRANULOSA (d'Archiac)
Plate 89, figure 3

Nummulites granulosa D'ARCHIAC (part), 1847, Bull. Soc. géol. France (2), vol. 4, p. 1010. See DAVIES in Davies and Pinfold, 1937, pp. 29, 30, for complete synonymy.

Davies (in Davies and Pinfold, 1937) gives evidence to show that the Indian type which d'Archiac referred to *A. granulosa* is the large smooth form which occurs in large numbers in the Nammal shales of the western Salt Range. There is nothing to add to the description of this form, but a median section (pl. 89, fig. 3) is included for comparison with that of the variety *A. granulosa chhumbiensis*. The Nammal form is, however, but one of a considerable range of varieties which occur at many horizons and localities in the Laki of the Kohat-Potwar basin. Nuttall (1925) described and illustrated a similar range of grading varieties from Sind and Baluchistan, including them, together with forms now recognised as the species *A. daviesi*, in the species *A. granulosa*. In 1937 (in Davies and Pinfold, 1937) Davies separated an end form common in the eastern Salt Range as the species *A. spinosa*, but recognised its relationship to *A. granulosa*. In the present work, an additional form, characteristic of the lower Bhadrar beds, is separated as the variety *A. granulosa chhumbiensis*.

The main characteristic which distinguishes *A. granulosa* and *A. spinosa* from other species in the Laki is the development of the spiral sheet, which is totally enveloping in the early whorls, but never completely enveloping in the later whorls.

Specimens which the author considers to be typical of the species *A. granulosa* have the following characteristics.

Maximum observed diameter is 15.4 mm., the larger forms being from the Nammal shales of the western Salt Range. The average diameter, however, is considerably less at about 9 mm. Externally, granulation is not prominent, the majority of specimens, especially those from lower Laki horizons, having a smooth appearance. The ornament becomes more evident on weathered specimens. Specimens with more pronounced ornament are forms that approach in appearance *A. spinosa* from the eastern Salt Range which, in all other respects, are identical with the type form. Ornament is in the form of granules along the lines of the junctions between septa and whorl, the granules are often so closely packed as to give the appearance of continuous "bar" structures, marking the septa.

ASSILINA GRANULOSA (d'Archiac),
var. CHHUMBIENSIS Gill, n. var.
Plate 89, figures 1, 2, 4, 5

The average diameter of this form is distinctly greater than that of any other *Assilina* recorded from the Laki of the Kohat-Potwar basin. The average of 10 adult specimens from the lower Bhadrar beds at Choa Saidan Shah is 10.4 mm., and the largest specimen from the same locality measures 16.5 mm. The external aspect differs from that of typical *A. granulosa* specimens in that the septa are almost invariably clearly marked by granules in the other two-thirds of the spire; in that the granules often scattered between the septa as well as on these and the whorl junctions are smaller and more uniform; and in that there is a raised boss at the poles as shown in plate 89, figs. 1, 3, and 4.

The size and general appearance are distinctly reminiscent of the Kirthar species *A. exponens;* the internal structure, however, in respect of the opening of the spire and the form of the septa is distinctly that of *A. granulosa;* the spire opens much more rapidly than any specimen of *A. exponens* in the author's collection.

The typical median section (pl. 89, fig. 5), shows chambers broader than is typical of *A. granulosa* from the Salt Range (pl. 89, fig. 3).

In the central Salt Range the form is very distinct, but at Tarki there is gradation in all aspects towards typical *A. granulosa*. As limestone facies develop to the west in the Salt Range, the variety *A. granulosa chhumbiensis* disappears from the lower

Bhadrar, and the representatives of the genus in the Jhunga section and other localities to the west are typical *A. granulosa*. The gradation at Tarki, and the facts of distribution suggest that the variety may be a mutation of the type form, rather than a normal morphological variant developed in the area of shale facies.

Distribution.—The form occurs in the lower Bhadrar beds of the Bakrala Ridge and the eastern Salt Range.

Cotypes.—P 41507, P 41520.

Assilina leymeriei (d'Archiac and Haime), 1853.

Nummulites leymeriei d'Archiac and Haime, 1853, Descr. des Animaux foss. du groups numm. de l'Inde (See this publication for complete synonymy.)

Davies (in Davies and Pinfold, 1937) did not describe or figure the megalospheric form of *A. granulosa* from the Salt Range. It occurs, however, in considerable numbers at most horizons with the microspheric form. Nuttall's figure of the Sind form (1925) seems nearer to *A. subspinosa*, but it is obvious that he included the same range of variations as in *A. granulosa*.

The author includes in *A. leymeriei* all the megalospheric forms having the same characteristics as *A. granulosa*, but differing only in size. In the Sakesar limestone of the eastern Salt Range there is gradation to *A. subspinosa*.

Assilina spinosa Davies, 1937

——, Carter, 1844, Jour. Bomb. Roy. Asiat. Soc., vol. 2, p. 43; pl. 8, figs. 12–12b.

Nummulites granulosa d'Archiac (part); Feddden, 1879, Mem. Geol. Surv. India, vol. 17, p. 199.

Assilina spinosa Davies, 1937, Pal. Ind., n.s. vol. 24, mem. no. 1, pp. 31–33.

This species is probably the end form of a series of gradations from *A. granulosa*. This gradation is seen in almost every community of specimens collected from the Sakesar limestone in the eastern Salt Range. There is nothing to add to Davies' description.

Subfamily Rotaliinae
Genus Rotalia

Rotalia trochidiformis Lamarck, 1804
Plate 90, figures 1–12

Rotalites (or *Rotalia*) *trochidiformis*, Lamarck, 1804, et. syn.

Rotalia newboldi d'Archiac and Haime, 1855 (part), Descr. des Animaux foss. du groups numm. de l'Inde, p. 347, pl. 36, figs. 17a–17c.

Dictyoconoides newboldi (d'Archiac and Haime), Davies, 1927.

Lockhartia newboldi (d'Archiac and Haime), Davies, 1932–1937.

It is surprising in view of his intimate knowledge of the types (1932), that Davies did not record this species from the Salt Range (Davies and Pinfold, 1937); for it is common at many horizons throughout the Ranikot and Laki. It seems probable, however, that most of the representatives of it were included in the species *Lockhartia newboldi*, which is here regarded as a normal morphological variation within the species *Rotalia trochidiformis*.

The range of variations of *R. trochidiformis* is very similar to the range of morphological variations which occurs in the genus *Dictyoconoides* in the Kirthar of northwest India. The author has demonstrated (1949) that in respect of shape and massiveness of the test, the variations in *Dictyoconoides* reflected the differences in environment in different localities of the Kohat-

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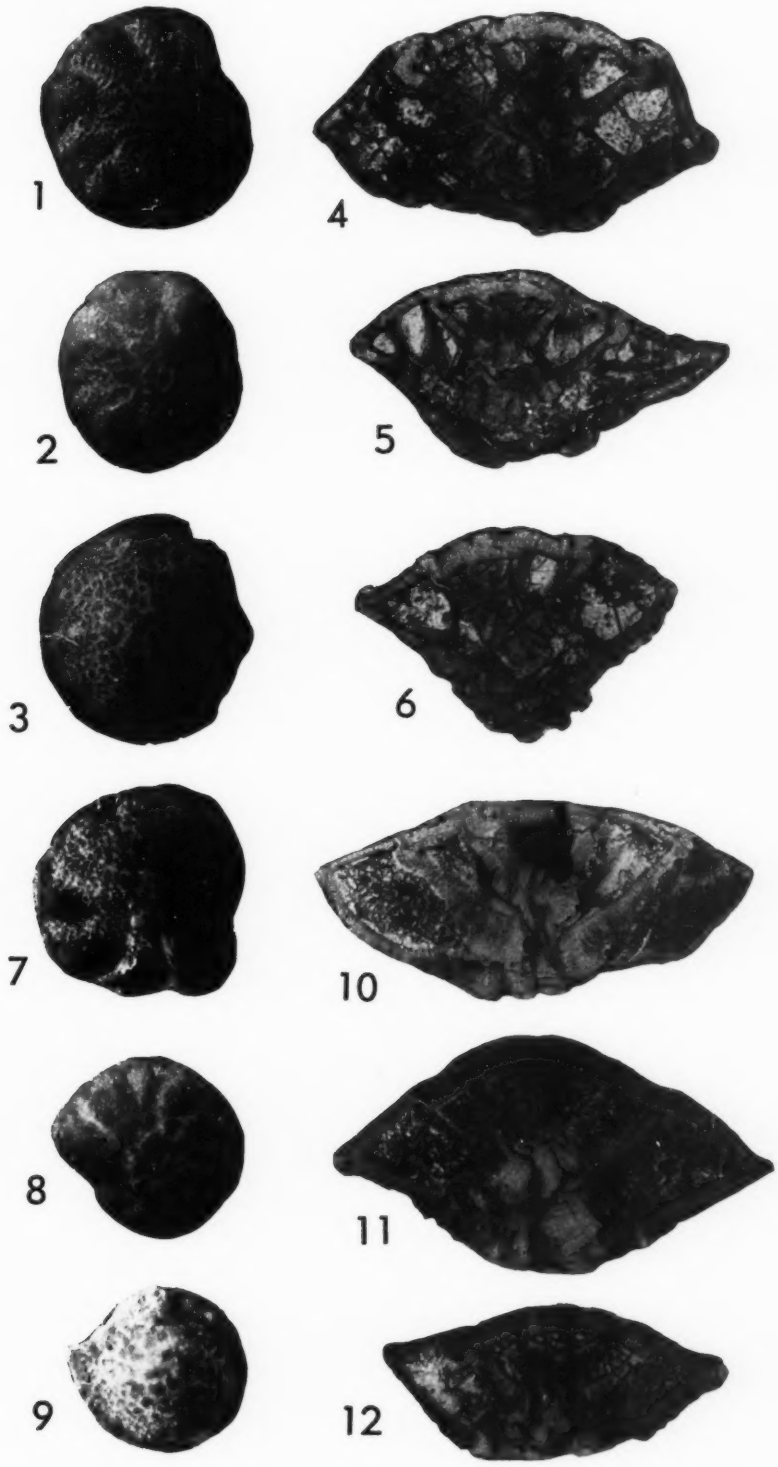
Explanation of Plate 90

Figs. *1–3*—*Rotalia trochidiformis* Lamarck. From the Khairabad limestone (Ranikot), Khairabad, Salt Range. Illustrating the variation in development of radial furrows and ornament of the lower chamber wall in a range of specimens whose shapes closely correspond with those of figs. *4*, *5*, and *6*. Basal views. All figures ×13. P.41531, P.41532, P.41533. (p. 840)

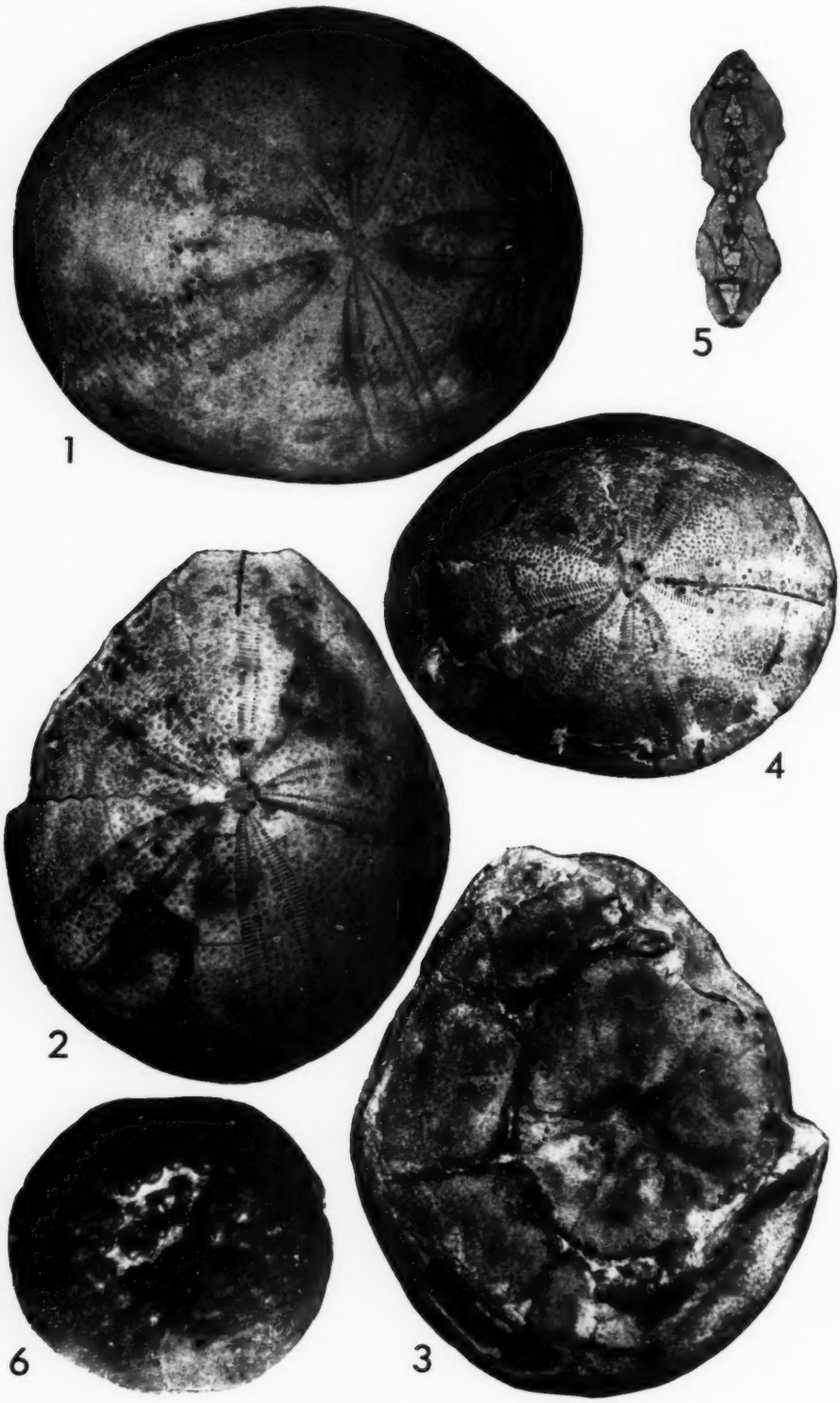
4–6—*Rotalia trochidiformis* Lamarck. Vertical sections showing variation in shape and internal structure of a closely similar range of specimens from the same locality as the specimens seen in basal view in figs. *1–3*. All figures ×23. P.41534, P.41535, P.41536. (p. 840)

7–9—*Rotalia trochidiformis* Lamarck. From the Khairabad limestone, southeast of Kallar Kahar. Illustrating a similar range of variation in basal aspect as in figs. *1–3*. All figures ×13. P.41537, P.41538, P.41539. (p. 840)

10–12—*Rotalia trochidiformis* Lamarck. Vertical sections showing variation in shape and internal structure of the forms from near Kallar Kahar, parallel with that seen in figs. *4–6*. All figures ×23. P.41540, P.41541, P.41542. (p. 840)



Gill, Eocene fauna from the Punjab Salt Range, Pakistan



Gill, Eocene fauna from the Punjab Salt Range, Pakistan

Potwar basin, and had no zonal significance.

Before describing the variations in *Rotalia* it is necessary to demonstrate that the "species" *Lockhartia newboldi* has been incorrectly ascribed to that genus.

Davies (1932) states that the following characters serve to distinguish *Rotalia* from *Lockhartia:*

1. The whorls are enveloping on the upper surface in *Rotalia.*
2. *Rotalia* possesses a marginal cord similar to that in *Nummulites*—a feature never seen in *Lockhartia.*
3. In *Rotalia,* the lower chamber wall extends well inside the umbilical area, giving an "intermediate area" between the umbilicus and the spire. In *Lockhartia* the umbilical area and the spire are sharply delineated.
4. In *Rotalia* the umbilical pillars are discontinuous, in contrast to the continuous pillars in *Lockhartia.*
5. *Rotalia* possesses secondary transverse structures at the base of the chambers known as "axial furrows" which are not present in *Lockhartia.*

Davies' published figure showing the internal structure of *L. newboldi* (1932, pl. 17, fig. 1) is of a vertical section which clearly shows the form to possess characters 1–4 previously detailed, and therefore to belong to the genus *Rotalia.* The basal aspect in all published illustrations is identical with that of many forms figured on plate 90.

Figures 1–6 on plate 90 are of specimens collected from the same bed about 100 feet from the base of the Khairabad limestone (Ranikot), near Khairabad in the western Salt Range. These form a part of an extensive series of specimens which were arranged according to shape, with the forms with convex upper surface and flat or slightly convex base at one end, through a series of gradations to forms with a slightly convex upper surface and high conical base at the other. From one of two closely similar sets of specimens, vertical sections were prepared. The arrangement of the specimens is preserved in plate 90, so that the shape of the specimens seen in basal view on the left (figs. 1–3) is approximately that of the vertical sections immediately to the right in figures 4–6.

In basal view a tendency is seen for the forms with a flatter base to be less coarsely granulated, but there is a similar range of granulations in specimens of all shapes.

The vertical sections show no variation in structure which can be correlated with any particular shape.

The development of umbilical pillars, formed from the clubbed and granulated inner ends of the lower chamber walls, varies, but is not more marked in figure 6 than in figure 3. It is also important to note that the puckering of the lower chamber wall to form the axial furrows is clearly seen in figures 4 and 6, i.e., in specimens representing the extremes of variation in shape.

Figures 7–12 are of specimens collected from the basal layers of the Khairabad limestone southeast of Kallar Kahar in the east central Salt Range. The same procedure and arrangement was adopted as for the Khairabad specimens.

The basal aspect is very similar in the specimens from both localities, though from Kallar Kahar, in some specimens with a high conical base, the granulations almost obliterate the radial furrows (fig. 9). A difference in internal structure is immediately apparent from the vertical sections. Irrespective of shape, the Kallar Kahar speci-

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EXPLANATION OF PLATE 91

FIG. *1*—*Conoclypeus pinfoldi* Gill, n. sp. From the lower Bhadrar beds, south of Dalwal, Salt Range. Holotype. Abactinal view. Natural size. E.40508. (p. 843)

2—*Conoclypeus pinfoldi* Gill, n. sp. From the lower Bhadrar beds, south of Dalwal. Abactinal view showing more detail of the apical disc. Natural size. Paratype. E.40509. (p. 843)

3—Actinal view of the same specimen. Natural size. (0. 843)

4—*Conoclypeus pilgrimi* Davies. From the lower Bhadrar beds, south of Dalwal. Abactinal view. ×½. E.40510. (p. 843)

5—*Assilina subdaviesi,* n. sp. From the lower Bhadrar beds, Nurpur (Salt Range). Median section. ×13.5. P.41543. (p. 838)

6—*Assilina subdaviesi* Gill, n. sp. From the lower Bhadrar beds, Dalwal (Salt Range). ×14. P.41544. (p. 838)

mens are more massively built. Both upper and lower chamber walls are thicker, but the most marked thickening is at the inner end of the lower chamber wall, where clubbing and pillar formation form a mass of shell structure in the umbilicus. In some cases, as in figure 11, the pillar structure may be continuous between two whorls; in figure 12 it appears to be continuous in one whorl across the umbilicus. The pillar structure of the umbilicus is, however, fundamentally a discontinuous, broken one; it is clearly a development of individual whorls—invariably so in the early whorls.

The relative width of the area of umbilical pillars varies considerably, increasing by encroachment on the "intermediate area" toward the chambers. There seems no doubt that in some cases the umbilical area also incorporates the axial furrow.

The differences between the Kallar Kahar specimens and those from Khairabad are completely explained by the greater deposition of shell material. All specimens are undoubtedly from the same stratigraphical level (this is proved by the associated foraminiferal fauna) so that the more massive tests from Kallar Kahar presumably reflect the reaction of the organism to different environmental conditions, possibly related to the concentration of carbonate in the water. The large numbers of specimens collected from many localities and many horizons in the Salt Range Eocene show the same range of variation as the specimens figured on plate 90, with no evidence that any variation is of importance from a zoning point of view. Without such evidence, it does not seem justifiable to separate off any variety from the species *Rotalia trochidiformis*.

Very thin shelled forms occur in the basal bed of the lower Bhadrar at Tarki, but on the main Salt Range, the Bhadrar beds form is usually of the more massive variety. The Ranikot specimens have been used for illustration because of their better state of preservation.

Subfamily ORBITOLITINAE

Genus ORBITOLITES Lamarck, 1801

ORBITOLITES COMPLANATUS Lamarck, 1801

Orbitolites complanata LAMARCK, 1801, Syst. An. sans Vert., 1st ed., p. 376.

See Davies in Davies and Pinfold, 1937, p. 56, for complete synonymy.

Well-preserved specimens of this species are common in the marly partings between the beds of upper Bhadrar limestone, east of Kallar Kahar. They weather out on the limestone surfaces showing the smooth surface with fine, concentric ribbing. A feature of this form is the irregularity of the median section compared with the very regular lateral section. This is due to the fact that the chamberlets of the annular chambers are not normal to the surface, but inclined at about 10–20° from the normal. Thus the median section usually passes through part of a chamberlet and part of a wall in any annulus. The median section also sometimes passes through the foramen between one annulus and the next, further adding to the irregular appearance of the median section.

Distribution.—*O. complanatus* has not appeared in the author's collections from the shaly facies of the lower Bhadrar of the Bakrala Ridge or from the Choa Saidan Shah area. In these localities it is abundant in the marly partings between the upper Bhadrar limestone beds. To the west, however, it appears abundantly in the porcellanous limestones in the limestone facies of the lower Bhadrar beds from Nurpur westwards. Though it occurs sporadically in the Sakesar limestone, the general flood of this species in the Kohat-Potwar basin does not occur until the upper Laki. It appears also in large numbers in the higher levels of the succeeding Kirthar.

Genus OPERTORBITOLITES Nuttall, 1925

OPERTORBITOLITES sp.

Appearing with *O. complanatus* in the sections of upper Bhadrar limestone from east of Kallar Kahar are undoubted representatives of this genus, the median section showing lateral laminae of shell substance on either side of the chamber layer. The laminae are not as thick, however, as those in *O. douvillei*, a species which occurs abundantly in cores of the upper Laki of the Dhulian oil field.

The central chamber layer as seen in equatorial section is thinner than that of *O. complanatus* but otherwise identical. The species is distinguished by its very large nuclear chambers, whose precise arrangement is not clear from the limited number of

sections available. There appear to be two or more large initial chambers, rather irregular in shape, followed by a ring of smaller chambers before the first annulus with regular chamberlets is seen.

Family ORIBTOLITINIDAE
Genera COSKINOLINA Stache, 1875
LITUONELLA Schlumberger and Douvillé, 1905

Although the *Dictyoconus* group of forms has so far been collected on the Salt Range only from a bed one foot in thickness near the top of the marine Laki at Jhunga, the sample of about a half pound of marl produced 26 specimens. Unfortunately, the preservation is very poor, the marginal trough being often almost completely weathered away and the specimens often distorted. Most of the better preserved specimens show the simple marginal trough and agree in shape with *Lituonella douvillei* Davies. Two specimens showed distinctly the simply divided marginal trough of *Coskinolina* on the exterior.

Distribution.—Dictyoconus group forms have not previously been recorded from the Salt Range. The described sections from Jhunga eastwards were sampled at equally close intervals, but the collections have been searched in vain. It is possible, however, that further sampling, especially in the limestone facies west of Jhunga, may extend considerably the geographical range on the Salt Range. The group occurs abundantly to the north of the Salt Range in a bed, usually less than 10 feet in thickness, at the top of the marine Laki limestone of the Balkassar and Dhulian oil fields, where it provides a valuable marker horizon. In the former locality the zone occurs in alternations of porcellanous limestone and shales recognisable as a calcareous facies of the lower Bhadrar beds (*Assilina daviesi* is common over a short range toward the base). At Dhulian the lower Bhadrar beds are no longer recognisable and the highest marine Laki beds are homogeneous porcellanous and detrital limestone.

At Joya Mair, 9 miles to the east of Balkassar, the lower Bhadrar beds are much more shaly. Paralleling the easterly development on the Salt Range, *A. daviesi* ranges throughout the lower Bhadrar beds. On the other hand, *Dictyoconus* group forms are absent.

The above facts of distribution clearly support the main conclusions of this paper and emphasise the importance of considering faunal phase when correlating the Eocene of the Kohat-Potwar basin.

Class ECHINOIDEA
Order EXOCYCLOIDA
Family DISCOIDIIDAE
Genus CONOCLYPEUS
CONOCLYPEUS PINFOLDI Gill, n. sp.
Plate 91, figures 1–3

In all, 22 specimens of echinoderms were collected from the area around Dalwal in the eastern Salt Range, from the lower Bhadrar beds. Of these only nine are sufficiently unbroken or adequately preserved to permit specific identification. These fall immediately into two distinct groups according to size. The larger form, 120 to 130 mm. long, is clearly *Conoclypeus pilgrimi*, Davies. There is nothing to add to the description of this species by Davies (1926, p. 359) but an abactinal view of the best preserved Salt Range specimen is given (pl. 91, fig. 4) for comparison with the smaller species, *C. pinfoldi*.

The three complete specimens of this species measure 75, 76, and 77 mm. in length, compared with an average of 126 mm. for the Salt Range *C. pilgrimi*.

The corona has more rounded contours, ovate rather than subconical. Its height is 46% of its length compared with 54% in *C. pilgrimi*. The apex is 7% eccentric to the front compared with 3% in *C. pilgrimi*. The poriferous zones of the "petals" are relatively narrow. The inter-poriferous zones are equal in width to the poriferous zones in the middle third of the petal and one-fifth wider towards the end of the petal. There are 68 pore pairs in the petal compared with 61 in *C. pilgrimi* from the same locality.

Another difference from the latter species is that there is no tumidity at the anterior ambital margin, nor of the inter-radial areas at their junction with the ambs.

The apical disc (pl. 91, figs. 1 and 2) and periproct appear to be identical with those of *C. pilgrimi*, but the peristome, seen in one specimen only (pl. 91, fig. 3) seems to

be considerably larger in proportion to the test.

The form is distinct from other species of *Conoclypeus* described from India, and is named after Mr. E. S. Pinfold, by whom I was introduced to the geology of northwest India.

Types.—Holotype, E 40508; paratype, E 40509.

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JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, PP. 845–846, 1 TEXT FIG., NOVEMBER 1953

SHALLOW PLEISTOCENE FOSSILS IN ST. TAMMANY PARISH, LOUISIANA

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DURING foundation investigations for the Southeast Louisiana Mental Hospital near Mandeville, St. Tammany Parish, Louisiana (see fig. 1), thin fossiliferous strata were encountered at depths of 15–30 feet in the Prairie formation of late Pleistocene age. This is not a unique occurrence since numerous shell strata have been encountered in excavations or holes of various kinds sunk into the Pleistocene sediments of south Louisiana (Harris, 1904; Howe, Russell, and McGuirt, 1935; Richards, 1938, 1939; Bridges, 1939; Bernard, 1940; Fisk, 1944, 1947, and unpublished reports; and others).

The composite sequence penetrated by three borings at the hospital site is:

PRAIRIE FORMATION

	Feet
Topsoil	2
Clayey sand and sandy clay; firm, brown and gray	7
Clay; gray, firm, and sandy with streaks of gray to brown sand	9
Sandy clay and clayey sand; firm, red	3
Clay; firm and gray with streaks of gray to brown sand	3
Silt; gray, soft, and clayey	1
Clay; blue-gray, firm, and sandy with streaks of red sand	3
Clay; blue-green, tough and firm, with thin fossiliferous streaks	18
Lignite and lignitic clay	2
Clay; brown, tough and firm	2

(Bottom not encountered)

Samples of the fossiliferous strata in these borings yielded a foraminiferal assemblage totalling 13 genera and 20 species. The forms present are (identifications by H. V. Andersen):

Angulogerina cf. A. occidentalis Cushman
Bolivina lowmani Phleger and Parker
Bolivina striatula Cushman
Bulimina exilis H. B. Brady var. (n. var.)
Buliminella elegantissima (d'Orbigny)
Chrysalidinella, n. sp.
Elphidium gunteri Cole (? var. galvestonensis Kornfeld)
Nonion grateloupi (d'Orbigny)
"Nonion" cf. N. depressulum (Walker and Jacob) var. matagordanum Kornfeld

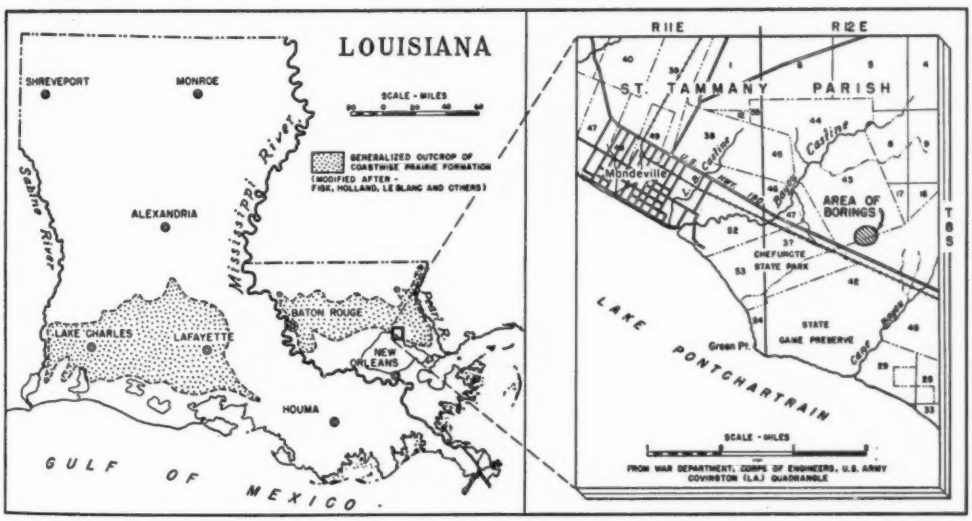

FIG. 1—Location map.

"Nonion" pauciloculum Cushman (Syn: "N." tisburyensis Butcher)
Nonionella cf. N. auris (d'Orbigny)
Quinqueloculina cf. Q. seminula (Linné)
Rectobolivina advena (Cushman)
Reussella atlantica Cushman
"Rotalia" beccarii (Linnaeus) var. parkinsoniana (d'Orbigny)
"Rotalia" beccarii (Linnaeus) var. tepida Cushman
Sigmomorphina sp.
Virgulina complanata Egger
Virgulina punctata d'Orbigny
Virgulina spinicostata Phleger and Parker

Repository.—Species listed are deposited in the H. V. Howe Collection, L. S. U. Geology Museum, Louisiana State University; numbers are 4180–4197 inclusive.

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BIBLIOGRAPHY AND INDEX TO NEW GENERA, SPECIES, AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1952

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ABSTRACT—The following bibliography lists, for the year 1952, 408 papers dealing partly or exclusively with Foraminifera or their use in stratigraphy. Sixty-seven titles are added for previous years.

The index to new genera, species, and varieties (subspecies) of Foraminifera for the year 1952 records as new: 4 suborders, 1 family, 6 subfamilies, 50 genera, 3 subgenera, 277 species, 34 varieties and subspecies, 26 nomina nova (of which 3 are genera, 18 species and 5 varieties), 5 homonyms (of which 2 have been renamed), 19 nomina nuda and 99 forms to which the nomenclatura aperta was applied. Supplementary listings for years prior to 1952 include as new: 2 genera, 10 species, 2 varieties, 5 forms with nomenclatura aperta and 1 homonym.

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—— *henbesti* Jordan and Applin, **214,** p. 4, pl. 2, figs. 1–4; pl. 3, figs. 1–3. Upper Jurassic (Portlandian), North Carolina, U.S.A.

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—— *quadrangularis* Uchio, **386,** p. 156, pl. 7, fig. 4. Recent, Japan.

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—— *cushmani* Todd and Kniker, **378,** p. 23, pl. 4, fig. 6. Upper Eocene, Chile.

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—— *nipponica* Asano and Inomata, **22,** p. 17, figs. 95, 96. Pliocene, Japan.

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—— *guerrai* Bermudez, **41,** p. 204, pl. 1, figs. 4–6. Middle Eocene, E. Mexico.

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—— *betieri* Drooger, **113,** p. 97, pl. 15, figs. 29, 30. Dano-Montian, Algeria.

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—— *paralica* Perconig, **301,** p. 131, pl. 2, figs. 3–5. Upper Miocene (paralic facies), N. Italy.

—— *parvula* Napoli Alliata, **285,** p. 99, pl. 5, fig. 11. Pleistocene (Calabrian), N. Italy.

—— *semiperforata* Lewis Martin, **260,** p. 129, pl. 21, figs. 10, 11. Pliocene, Los Angeles Basin, California, U.S.A.

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BUCCELLA, gen. nov. Andersen, **10,** p. 143. New genus of the family Rotaliidae. Genotype: *Eponides hannai* Phleger and F. L. Parker, 1951, Geol. Soc. America, Mem. 46, p. 21, pl. 10, figs. 11–14. Oligocene to Recent.

—— *depressa* Andersen, **10,** p. 145, text figs. 7, 8. Recent, Port Williams, Falklands, 8–10 fathoms.

—— *inusitata* Andersen, **10,** p. 148, text figs. 10, 11. Recent, off Coast of Washington, U.S.A., Pacific.

—— *parkerae* Andersen, **10,** p. 149, text fig. 9. Miocene (Temblor), California, U.S.A.

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BULBOPHRAGMIUM gen. nov. Maync, **262,** p. 46. New genus of the family Lituolidae, subfam. Lituolinae. Genotype: *Haplophragmium aequale* Reuss, 1860, Sitzber. k. Akad. Wiss. Wien, vol. 40, p. 218, pl. 11, fig. 2a. Lower to middle Cretaceous.

Bulimina aquafrescaensis Todd and Kniker, **378,** p. 22, pl. 4, fig. 5. Upper Eocene, Chile.

—— *arndti* Hagn, **175,** p. 168, pl. 2, fig. 15. Upper Oligocene (Chattian), Bavaria, Germany.

—— *marginata* Orbigny, 1826, var. *grandissima* Lewis Martin, **260,** p. 131, pl. 23, fig. 1. Pliocene, Los Angeles Basin, California, U.S.A.

—— *marksi* Drooger, **113,** p. 95, pl. 15, figs. 17–19. Dano-Montian, Aigeria

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—— *tenuis* Napoli Alliata, **285,** p. 100, pl. 5, figs. 4, 6. Pleistocene (Calabrian), N. Italy. (Note: Preoccupied by Phleger and F. L. Parker, 1951, Geol. Soc. America, Mem. 46, pt. 2, p. 16, pl. 7, figs. 33, 34, for a Recent species from the NW Gulf of Mexico.)

Cancris bavaricus Knipscheer, **225,** p. 64, text fig. 4. Aquitanian, Bavaria, Germany.

—— *vicksburgensis* Todd, **375,** p. 41, pl. 6, fig. 1 Middle Oliogocene (Vicksburg), Mississippi, U.S.A.

CARIBEANELLA gen. nov. Bermudez, **40,** p. 121. New genus of the family Planorbulinidae, subfam. Planorbulininae. Genotype: *Caribeanella polystoma* Bermudez, 1952, ut infra. Recent.

—— *polystoma* Bermudez, **40,** p. 121, pl. 27, fig. 18. Recent, Bahamas, Caribbean Sea, 7½ fathoms.

Cassidulinoides bodeni Hagn, 175, p. **181,** pl. 2, fig. 12. Chattian, Bavaria, Germany.

CHARLTONINA gen. nov. Bermudez, **40,** p. 69. New genus of the family Rotaliidae, subfam. Siphonininae. Genotype: *Pseudoparrella madrugaensis* Cushman and Bermudez, 1948, Cushman Lab. Foram. Res. Contr., vol. 24, p. 73, pl. 12, figs. 11–13. Upper Cretaceous to Paleocene.

Chilostomella fakrounensis Marks, **259,** p. 289, pl. 1, figs. 30–33. Miocene, Algeria.

Choffatella zireggensis Sigal, **336,** p. 12, text fig. 4. Lower Cretaceous, Hauterivian, Algeria.

CHRYSALIDINOIDES gen. nov. Uchio, **386,** p. 154. New genus of the family Buliminidae, subfam. Reussellinae. Genotype: *Chrysalidinoides pacificus* Uchio, 1952, ut infra. Recent.

—— *pacificus* Uchio, **386,** p. 154, pl. 7, fig. 6. Recent, Japan.

Chrysalogonium magallanicum Todd and Kniker, **378,** p. 16, pl. 3, figs. 11–13. Upper Eocene, Chile.

—— *vicksburgense* Todd, **375,** p. 13, pl. 2, figs. 13–15. Middle Oligocene (Vicksburg), Mississippi, U.S.A.

Cibicides djaffaensis Sigal, **336,** p. 14, text fig. 5. Hauterivian, Algeria.

—— *italicus* Napoli Alliata, **284,** p. 3, pl. 1, figs. 1–7. Tortonian, Italy.

—— *mckannai* Galloway and Wissler 1927 var. *suppressus* Lewis Martin, **260,** p. 126, pl. 20, fig. 3. Pliocene, Los Angeles Basin, California, U.S.A.

—— *(?) omurai* Asano and Inomata, **22,** p. 17, figs. 97–99. Miocene, Japan.

—— *ungerianus* (Orbigny, 1846) var. *filicosta* Hagn, **175,** p. 186, pl. 1, fig. 4. Chattian, Bavaria, Germany.
—— *yabei* Asano, **20,** p. 43, pl. 4, fig. 1. Oligocene, Hokkaido, Japan.
Cibicidoides cederstromi McLean, 1951, var. *vincentownensis* McLean, **266,** p. 12, pl. 3, figs. 6, 9. Paleocene, New Jersey, U.S.A.
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Clavulinoides brunswickensis Todd and Kniker, **378,** p. 11, pl. 2, fig. 1. Upper Eocene, Chile.
—— *chilena* Todd and Kniker, **378,** p. 11, pl. 2, figs. 2–4. Upper Eocene, Chile.
Cornuspira cushmani Todd and Kniker, **378,** p. 13, pl. 2, fig. 18. Upper Eocene, Chile.
CRIBROTEXTULARIA gen. nov. Loeblich and Tappan, **246,** p. 81. New genus of the family Textulariidae. Genotype: *Textularia coryensis* Cole, 1941, Florida Geol. Surv. Bull. 19, p. 21, pl. 1, fig. 13. Middle Eocene. (Note: this new genus has since been declared as a junior synonym to *Olssonina* Bermudez, 1949, by the authors, The Micropaleont., vol. 7, no. 2, 1953, p. 45.)
Cristellaria ouachensis Sigal, **338,** p. 16, text fig. 10. Hauterivian, Algeria.
Cushmanella excentrica Napoli Alliata, **285,** p. 105, pl. 5, fig. 1. Upper Pliocene (Astian), N. Italy.
Cyclammina japonica Asano, 1949, var. *kaiensis* Fukuta and Shinoki, **148,** p. 202, pl. 6, figs. 1–4. Middle Miocene, Japan.
CYLINDROCLAVULINA gen. nov. Bermudez and Key, **42,** p. 76. New genus of family Valvulinidae. Genotype: *Clavulina bradyi* Cushman, 1911, U. S. Nat. Mus., Bull. 71, pt. 2, p. 73, figs. 118–119. Eocene to Recent.
Cymbaloporetta hemisphaerica Accordi and Selmi, **3,** p. 95, pl. 2, figs. 18, 19. Pliocene, Italy.
Dentalina elgansoensis Todd and Kniker, **378,** p. 15, pl. 3, fig. 16. Upper Eocene, Chile.
—— *johnsoni* McLean, **266,** p. 6, pl. 2, figs. 4, 7. Paleocene, New Jersey, U.S.A.
—— *klineae* McLean, **266,** p. 6, pl. 2, figs. 5, 8. Paleocene, New Jersey, U.S.A.
—— *monroei* Todd, **375,** p. 12, pl. 2, fig. 6. Middle Oligocene (Vicksburg), Mississippi, U.S.A.
—— *patagonica* Todd and Kniker, **378,** p. 16, pl. 3, fig. 15. Upper Eocene, Chile.
—— *subguttifera* Bartenstein, **33,** p. 310. Upper Barremian, Germany. For: *Nodosaria* D59 Hecht, 1938, Abhandl. Senckenberg. Natf. Ges. No. 443, pl. 10b, figs. 59, 60.
Dictyoconus daviesi Silvestri, 1939, var. *maior* Azzaroli, **25,** p. 117, pl. 8, figs. 15–19. Eocene, Somalia.
Discocyclina rudis Azzaroli, **25,** p. 128, pl. 13, figs. 9–11; pl. 14, figs. 1–5. Eocene, Somalia.
—— *somaliensis* Azzaroli, **25,** p. 127, pl. 13, fig. 2; pl. 16, fig. 6. Eocene, Somalia.
Discorbis djaffaensis Sigal, **338,** p. 17, text fig. 13. Barremian, Algeria.
—— *laquei* Church, **72,** p. 375, pl. 20, figs. 1, 5, 8. Pacific Ocean, off California, Recent, 85–92 fathoms.
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—— *squamata* F. L. Parker, **299,** p. 418, pl. 6, figs. 10, 11. Recent, Atlantic, off New Hampshire, U.S.A., 29 m.
—— *tentoria* Todd, **375,** p. 35, pl. 5, fig. 4. Middle Oligocene (Vicksburg), Mississippi, U.S.A.
DUSENBURYINA gen. nov. Bermudez and Key, **42,** p. 73. New genus of the family Valvulinidae. Genotype: *Clavulina procera* Goes, 1889, K. Svensk. Vet.-Akad. Handl., vol. 15, pt. 4, no. 2, p. 9, pl. 2, fig. 17. Recent.
Elphidium aguafrescaense Todd and Kniker, **378,** p. 19, pl. 3, fig. 36. Upper Eocene, Chile.
—— *chilenum* Todd and Kniker, **378,** p. 19, pl. 3, fig. 37. Upper Eocene, Chile.
—— *hiltermanni* Hagn, **175,** p. 163, pl. 1, fig. 6; pl. 2, fig. 14. Upper Rupelian, Bavaria, Germany.
—— *lauritaense* Todd and Kniker, **378,** p. 19, pl. 3, fig. 38. Upper Eocene, Chile.
—— *patagonicum* Todd and Kniker, **378,** p. 18, pl. 3, fig. 35. Upper Eocene, Chile.
—— *skyringense* Todd and Kniker, **378,** p. 18, pl. 3, fig. 39. Upper Eocene, Chile.
Entosolenia echigoensis Asano and Inomata, **22,** p. 7, figs. 35, 36. Pliocene, Japan.
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—— *tokaoi* Asano, **21,** p. 48, pl. 6, fig. 3. Miocene, Hokkaido, Japan.
Eorupertia incrassata (Uhlig, 1886) var. *laevis* Grimsdale, **165,** p. 239, pl. 20, figs. 15–21. Middle Eocene, Middle East and Turkey.
EPISTOMARIOIDES gen. nov. Uchio, **386,** p. 158. New genus of the family Rotaliidae, subfam. Siphonininae. Genotype: *Discorbina polystomelloides* Parker and Jones, 1865, Phil. Trans., vol. 155, p. 481, pl. 19, fig. 8. Recent.
Epistomina auresensis Sigal, **338,** p. 8, text fig. 1. Berriasian, Algeria.
—— *djaffaensis* Sigal, **338,** p. 14, text fig. 7. Hauterivian, Algeria.
Eponidella gardenislandensis Akers, **4,** p. 648, text fig. 2. Recent, Garden Island Bay, Gulf of Mexico.
Eponides frigidus (Cushman, 1922) var. *granulatus* Napoli Alliata, **285,** p. 103, pl. 5, fig. 3. Upper Pliocene (Astian), N. Italy.
Eulepidina, see *Lepidocyclina*.
Flosculina sicula de Stefani, **348,** p. 5, pl. 1, fig. 3. Middle Eocene, Sicily, Italy.
—— *silvestrii* de Stefani, **348,** p. 6, pl. 1, figs. 4, 5. Lutetian, Friuli, Italy.
Frankeina djaffaensis Sigal, **338,** p. 15, text fig. 8. Hauterivian, Algeria.
Frondicularia deflaensis Sigal, **338,** p. 39, text fig. 44. Upper Cretaceous, Algeria.
—— *herpersi* McLean, **266,** p. 8, pl. 3, fig. 8. Paleocene, New Jersey, U.S.A.
—— *howei* McLean, **266,** p. 99, pl. 2, figs. 1–3, 6. Paleocene, New Jersey, U.S.A.
—— *obliquecostata* Usbeck, **389,** p. 394, pl. 18, fig. 47; text fig. 4. Lower Liassic, Suavia, Germany.
—— *pitmani* McLean, **266,** p. 9, pl. 1, figs. 7–10, 12. Paleocene, New Jersey, U.S.A.

—— *pseudosulcata* Barnard, **30,** p. 342, fig. A, no. 4. Oxfordian, England.
Gaudryina brunswickensis Todd and Kniker, **378,** p. 10, pl. 1, figs. 24–26. Upper Eocene, Chile.
—— *chettabaensis* Sigal, **338,** p. 11, text fig. 2. Valanginian, Algeria.
—— *chileana* Todd and Kniker, **378,** p. 10, pl. 1, figs. 15, 22, 23. Upper Eocene, Chile.
—— *inflata* Carbonnier, **66,** p. 112, pl. 5, fig. 1. Upper Cenomanian, Morocco. (Note: Preoccupied by Israelsky, 1951, U. S. Geol. Survey Prof. Pap. 240-A, p. 16, pl. 6, figs. 1–12 for a Paleocene species of California, and re-named by Carbonnier: *Gaudryina tazaensis* nom. nov. 1953, Soc. geol. France, Comptes rendus, p. 20.)
—— (*Siphogaudryina*) *howelli* McLean, **266,** p. 5, pl. 3, figs. 11–14. Paleocene, New Jersey, U.S.A.
Gaudryinella sherlocki Bettenstaedt, **44,** p. 268, pl. 1, figs. 1–5. Middle Barremian, N.W. Germany.
Gavelinella barremiana Bettenstaedt, **44,** p. 275, pl. 2, figs. 26–29. Middle Barremian, N.W. Germany.
—— *cuvillieri* Carbonnier, **66,** p. 114, pl. 5, fig. 8. Upper Cenomanian, Morocco.
GINESINA gen. nov. Bermudez and Key, **42,** p. 72. New genus of the family Reophacidae. Genotype: *Ginesina delicatula* Bermudez and Key, 1952, ut infra. Recent.
—— *delicatula* Bermudez and Key, **42,** p. 72, text fig. 1. Recent, Caribbean Sea, off Cuba, 570 fathoms.
Globigerina aissana Sigal, **338,** p. 28, text fig. 30. Cenomanian, Algeria.
—— *aumalensis* Sigal, **338,** p. 28, text fig. 29. Cenomanian, Algeria.
—— *finlayi* Bronnimann, **60,** p. 18, pl. 2, figs. 10–12. Paleocene, Trinidad.
—— *gautierensis* Bronnimann, **59,** p. 11, pl. 1, figs. 1–3. Upper Cretaceous, Trinidad.
—— *gravelli* Bronnimann, **60,** p. 12, pl. 1, figs. 16–18. Paleocene, Trinidad.
—— *hornibrooki* Bronnimann, **60,** p. 15, pl. 2, figs. 4–6. Paleocene, Trinidad.
—— *panormensis* de Stefani, **347,** p. 9. Described, but not figured. Miocene, Sicily, Italy.
—— *paradubia* Sigal, **338,** p. 28, text fig. 28. Cenomanian, Algeria.
—— *patagonica* Todd and Kniker, **378,** p. 26, pl. 4, fig. 32. Upper Eocene, Chile.
—— *soldadoensis* Bronnimann, **60,** p. 9, pl. 1, figs. 1–9. Paleocene, Trinidad.
—— *stainforthi* Bronnimann, **60,** p. 23, pl. 3, figs. 10–12. Paleocene, Trinidad.
—— *taroubaensis* Bronnimann, **60,** p. 18, pl. 2, figs. 16–18. Lower Eocene, Trinidad.
GLOBIGERINATHEKA gen. nov. Bronnimann, **57,** p. 27. New genus of the family Globigerinidae. Genotype: *Globigerinatheka barri* Bronnimann, 1952, ut infra. Upper Eocene.
—— *barri* Bronnimann, **57,** p. 27, text fig. 3 a–h. Upper Eocene, Trinidad.
Globigerinella escheri (Kaufmann, 1865) subsp. *clavata* Bronnimann, **59,** p. 49, pl. 1, figs. 12, 13; text figs. 24–26. Turonian-Senonian, Trinidad.
—— *messinae* Bronnimann, 1952 subsp. *messinae* Bronnimann, **59,** p. 42, pl. 1, figs. 6, 7; text fig. 20. Upper Cretaceous, Trinidad.
—— —— —— subsp. *subcarinata* Bronnimann, **59,** p. 44, pl. 1, figs. 10, 11; text fig. 21. Upper Maestrichtian, Trinidad.
—— (*?*) *tururensis* Bronnimann, **59,** p. 51, pl. 1, figs. 4, 5; text fig. 27. Cenomanian, Trinidad.
Globigerinoides sicana de Stefani, **347,** p. 9. Described, not figured. Miocene, Sicily, Italy. For: *Globigerinoides conglobata* (Brady) in: Cushman and Stainforth, 1945, Cushman Lab. Foram. Res., Spec. Publ. 14, p. 60, pl. 13, fig. 6, Miocene, Trinidad.
GLOBIGERINOITA gen. nov. Bronnimann, **57,** p. 26. New genus of the family Globigerinidae. Genotype: *Globigerinoita morugaensis* Bronnimann, 1952, ut infra. Miocene.
—— *morugaensis* Bronnimann, **57,** p. 26, text figs. 1 a–m; 2 a–h. Miocene, Trinidad.
Globorotalites bartensteini Bettenstaedt, 1952, subsp. *bartensteini* Bettenstaedt, **44,** p. 280, pl. 3, fig. 30; pl. 4, figs. 33–47. Lower to middle Barremian, N.W. Germany.
—— —— —— subsp. *aptiensis* Bettenstaedt, **44,** p. 282, pl. 3, fig. 32; pl. 4, figs. 59–72. Lower Aptian, N.W. Germany.
—— —— —— subsp. *intercedens* Bettenstaedt, **44,** p. 281, pl. 3, fig. 31; pl. 4, figs. 48–58. Higher middle Barremian, N.W. Germany.
—— *djaffaensis* Sigal, **338,** p. 19, text fig. 15. Barremian, Algeria.
—— *ouachensis* Sigal, **338,** p. 19, text fig. 14. Barremian, Algeria.
GLOBOSIPHON gen. nov. Avnimelech, **23,** p. 65. A new genus of the suborder Monothalamia Avnimelech, 1952, ut infra, subfam. Psammosiphonellinae Avnimelech, 1952, ut infra. Genotype: *Pelosina variabilis* Brady, 1879, var. *sphaeriloculum* Hoglund, 1947, Uppsala Univ., Zool. Bidr., vol. 26, p. 61, pl. 6, figs. 8–11. Silurian and Recent.
Globotruncana asymetrica Sigal, **338,** p. 35, text fig. 35. Turonian-Coniacian, Algeria.
—— *falsostuarti* Sigal, **338,** p. 43, text fig. 46. Maestrichtian, Algeria.
—— *lamellosa* Sigal, **338,** p. 42, text fig. 45. Maestrichtian, Algeria.
—— *schneegansi* Sigal, 338, p. 33, text fig. 34. Turonian-Coniacian, Algeria.
—— (*Rotalipora*) *turonica* Brotzen, 1942, var. *expansa* Carbonnier, 66, p. 118, pl. 6, fig. 4. Upper Cenomanian, Morocco.
Gümbelina (*Ventilabrella*) *deflaensis* Sigal, **338,** p. 37, text fig. 41. Turonian-Coniacian, Algeria.
Gyroidina mauretanica Carbonnier, **66,** p. 113, pl. 5, fig. 5. Upper Cenomanian, Morocco.
Haplophragmoides chilenum Todd and Kniker, **378,** p. 6, pl. 1, figs. 10, 11. Upper Eocene, Chile.
HAPLOPHRAGMOIDINAE subfam. nov. Maync, **262,** p. 43. New subfamily of the family Lituolidae Brady. Includes the genera: *Haplophragmoides* Cushman, 1910; *Cribrostomoides* Cushman, 1910, *Trochamminoides* Cushman, 1910, and *Recurvoides* Earland, 1934.
Hastigerinella (*Hastigerinoides*) *rohri* Bronnimann, **59,** p. 55, pl. 1, figs. 8, 9; text fig. 29. Cenomanian, Trinidad.

HASTIGERINOIDES subgen. nov. Bronnimann, **59,** p. 52. A new subgenus of the genus *Hastigerinella* Cushman, 1927. Subgenotype: *Hastigerinella alexanderi* Cushman 1931, Contr. Cushman Lab. Foram. Res., vol. 7, p. 87, pl. 11, figs. 6–9. Family: Globigerinidae. Upper Cretaceous.

Hastigerinoides see *Hastigerinella.*

HEMIGYPSINA gen. nov. Bermudez, **40,** p. p. 124. New genus of the family Planorbulinidae, subfam. Gypsininae. Genotype: *Gypsina mastelensis* Bursch, 1947, Schweiz. Paläont. Abhandl., vol. 65, p. 37, pl. 3, figs. 15, 19; pl. 5, fig. 4; text figs. 15, 17–19. Tertiary.

Heterillina hensoni Grimsdale, **165,** p. 228, pl. 20, figs. 1–6; text figs. 2, 3. Oligocene, Kirkuk, Iraq.

Heterostomella chettabaensis Sigal, **338,** p. 11, text fig. 3. Valanginian, Algeria.

HOFKERINELLA gen. nov. Bermudez, **40,** p. 74. New genus of the family Rotaliidae, subfam. Rotaliinae. Genotype: *Nautilus balthicus* Schroeter, 1783, Einleit. Conch. Kenntn., vol. 1, p. 20, pl. 1, fig. 2. Recent.

Idalina sinjarica Grimsdale, **165,** p. 230, pl. 20, figs. 11–14. Paleocene, Iraq.

Karreriella siphonella (Reuss, 1851) var. *exilis* Hagn, **175,** p. 139, pl. 1, fig. 7. Rupelian, Bavaria, Germany.

Labrospira arctica F. L. Parker, **299,** p. 3999, pl. 2, figs. 7, 12. Recent, Arctic, Baffin Bay, 629 m.

Laffitteina conica Drooger, **113,** p. 100, pl. 16, figs. 10, 16, 17. Dano-Montian, Algeria.

—— *vanbelleni* Grimsdale, **165,** 232, pl. 22, figs. 3–11. Lower Eocene, Iraq, Syria, France.

Lagena biagensis Perconig, **301,** p. 131, pl. 2, figs. 6, 7. Upper Miocene, Italy.

LAMELLODISCORBIS gen. nov. Bermudez, **40,** p. 39. New genus of the family Rotaliidae, subfam. Discorbisinae. Genotype: *Discorbina dimidiata* Parker and Jones, 1862, Introduct. Study Foram., p. 201, text figs. 9, 32. Recent.

Lenticulina (*Lenticulina*) *heiermanni* Bettenstaedt, **44,** p. 270, pl. 1, figs. 9–11. Middle Barremian, N.W. Germany.

—— (——) *wisselmanni* Bettenstaedt, **44,** p. 269, pl. 1, figs. 6–8. Lower Barremian, N.W. Germany.

—— (*Saracenaria*) *forticosta* Bettenstaedt, **44,** p. 271, pl. 1, fig. 12; pl. 2, figs. 13, 14. Middle Barremian, N.W. Germany.

Lepidocyclina (*Eulepidina*) *badjirraensis* Crespin, **90,** p. 29, pl. 6, figs. 1, 2, 5; pl. 7, figs. 1, 2, 4; pl. 8, figs. 1–5. Miocene (Aquitanian), N.W. Australia.

—— (——) *manduensis* Crespin, **90,** p. 30, pl. 6, figs. 3, 4; pl. 7, figs. 3, 5, 6; pl. 8, figs. 6, 7. Miocene (Aquitanian), N.W. Australia.

—— (*Pliolepidina*) *gubernacula* Cole, **80,** p. 15, pl. 8, figs. 9–14; pl. 9, figs. 1, 2; pl. 12, fig. 16; pl. 20, fig. 17; pl. 23, fig. 13. Upper Eocene, Panama.

Leptodermella variabilis F. L. Parker, **300,** p. 452, pl. 1, figs. 11, 12. Recent, Long Island Sound, 6½ m. U.S.A.

Lingulina vincentownensis McLean, **266,** p. 8, pl. 1, fig. 11. Paleocene, New Jersey, U.S.A.

Lituola spinifera Maync, **262,** p. 64, pl. 10, figs. 4, 5. Upper Cretaceous (Taylor), Texas, U.S.A.

Lituola westfalica Bartenstein, 1952, subsp. *hannoverana* Bartenstein, **34,** p. 324, pl. 1, fig. 15; pl. 5, figs. 8–10. Lower Campanian, N.W. Germany.

—— —— —— subsp. *westfalica* Bartenstein, **34,** p. 323, pl. 1, figs. 5, 6, 15; pl. 5, figs. 1–6. Upper Campanian, N.W. Germany.

Lituonella depressa Azzaroli, **25,** p. 115, pl. 8, figs. 1, 4, 5, 7. Eocene, Somalia.

—— *dispansa* Azzaroli, **25,** p. 115, pl. 5, fig. 3; pl. 8, figs. 2, 3, 6; pl. 11, fig. 10. Eocene, Somalia.

Lituotuba chileana Todd and Kniker, **378,** p. 5, pl. 1, figs. 6–8. Upper Eocene, Chile.

Loxostomum chalkophilum Hagn, **175,** p. 172, pl. 2, fig. 11. Rupelian, Bavaria, Germany.

Loxostoma (recte: *Loxostomum*) *perforatum* Napoli Alliata, **285,** p. 101, pl. 5, fig. 9. Upper Pliocene (Astian), N. Italy.

—— (——) *pseudodigitale* Napoli Alliata, **285,** p. 102, pl. 5, fig. 8. Upper Pliocene (Astian), N. Italy.

Marginulina bachei Bailey, 1851, var. *africana* Marks, **259,** p. 286, pl. 1, figs. 6–8. Miocene, Algeria. (Note: Preoccupied by Muraour, 1949, Bull. Carte géol. Algérie, (1), Paléont., no. 10, pt. 2, p. 109, pl. 2, figs. 22, 23, for an Algerian lower Pliocene species).

—— *martinsi* de Stefani, **347,** p. 8, not figured, only described. Miocene, Sicily, Italy.

Marginulinopsis djaffaensis Sigal, **338,** p. 15, text fig. 9. Hauterivian, Algeria.

Marssonella ouachensis Sigal, **338,** p. 19, text fig. 16. Barremian, Algeria.

Meandropsina djaffaensis Sigal, **338,** p. 17, text fig. 12. Barremian, Algeria.

MICATUBA gen. nov. Avnimelech, **23,** p. 65. New genus of the suborder Monothalamia Avnimelech, 1952, ut infra, subfam. Micatubinae Avnimelech, 1952, ut infra. Genotype: *Bathysiphon flexilis* Hoglund, 1947, Uppsala Univ., Zool. Bidr., vol. 26, p. 42, text figs. 10, 11. Recent.

MICATUBINAE new subfam. Avnimelech, **23,** p. 65. New subfamily of the suborder Monothalamia Avnimelech, 1952, ut infra. Only genus: *Micatuba* Avnimelech, 1952, ut supra.

MICROMETULA gen. nov. Nyholm, **290,** p. 15. New genus of the family Allogromiidae. Genotype: *Micrometula hyalostriata* Nyholm, 1952, ut infra. Recent.

—— *hyalostriata* Nyholm, **290,** p. 15, pl. 4, figs. 1–10; pl. 5, fig. 8. Recent, Skagerak, Sweden.

Miliammina echigoensis Asano and Inomata, **22,** p. 5, figs. 21–24. Miocene, Japan.

Millerella gigantea Kanmera, **216,** p. 172, pl. 12, figs. 4–14. Lower Carboniferous, Japan.

—— *japonica* Kanmera, **216,** p. 170, pl. 11, figs. 1–19; pl. 12, figs. 1, 2. Lower Carboniferous, Japan.

MILLETTINA gen. nov. Avnimelech, **23,** p. 64. New genus of the suborder Monothalamia Avnimelech, 1952, ut infra, subfam. Argillotubinae Avnimelech, 1952, ut supra. Genotype: *Pelosina distoma* Millett, 1904, Jour. R. Micr. Soc. London, p. 608, pl. 11, figs. 5, 6. Recent.

Miogypsina (*Miogypsina*) *intermedia* Drooger,

112, p. 35, pl. 2, figs. 30–34; pl. 3, fig. 4. Upper Oligocene, Cuba.
—— (——) *tani* Drooger, **112,** p. 26, pl. 2, figs. 20–24; pl. 3, fig. 2. Middle Oligocene, Costa Rica.
—— (——) *thalmanni* Drooger, **112,** p. 15, pl. 1, figs. 1–5; pl. 2, figs. 1–5; pl. 3, fig. 1. Middle Oligocene, Dominican Republic.
MIOGYPSINITA subgen. nov. Drooger, **112,** p. 58. New subgenus of the genus *Miogypsina* Sacco, 1893. Family: Miogypsinidae. Subgenotype: *Miogypsina mexicana* Nuttall, 1933, Jour. Paleontology, vol. 7, p. 175, pl. 24, figs. 1–6, 8, 10, 12. Upper Oligocene.
Miogypsina (*Miogypsinita*) *bronnimanni* Drooger, **112,** p. 28, pl. 1, figs. 35–39; pl. 3, fig. 1. Upper Oligocene, Trinidad.
MONOTHALAMIA new suborder, Avnimelech, **23,** p. 63. Comprises the subfamilies: Amphitreminae Galloway emend. Avnimelech, 1952, and the new subfamilies (Avnimelech, 1952): Argillotubinae, Bathysiphoninae, Micatubinae, Psammosiphonellinae, and Testulosiphoninae.
MOSCOVIELLA gen. nov. Miklukho-Maklai, **270,** p. 991. New genus of the family Fusulinidae. Genotype: *Reichelina cribroseptata* (Erk, 1941). Upper Paleozoic. (Note: This reference is quoted from G. W. Sinclair, Biol. Abstracts, vol. 27, no. 5, May 1953, no. 14458, who states that the new genus is "phylogenetically intermediate between *Eostaffella* and *Reichelina.*" This new genus, however, is invalid, because the cited genotype is already the genotype for *Reichelina* Erk, 1941.
Neoflabellina buticula Hiltermann, **190,** p. 53, fig. 3, no. 58. Campanian, N.W. Germany.
—— *praereticulata* Hiltermann, **190,** p. 53, fig. 3, no. 37. Uppermost Campanian, N.W. Germany.
—— *praerugosa* Hiltermann, **190,** p. 53, fig. 3, nos. 12–14. Coniacian (Emescherian), N.W. Germany.
NEOROTALIA gen. nov. Bermudez, **40,** p. 75. New genus of the family Rotaliidae, subfam. Rotaliinae. Genotype: *Rotalia mexicana* Nuttall, 1928, Jour. Paleontology, vol. 2, p. 374, pl. 50, figs. 6–8. Upper Cretaceous to Oligocene.
Nodosaria richardsi McLean, **266,** p. 7, pl. 2, figs. 13–16. Paleocene, New Jersey, U.S.A.
Nonion compressum Napoli Alliata, **285,** p. 969, pl. 5, fig. 2. Pleistocene (Calabrian), N. Italy. (Note: Preoccupied by Roemer, 1841, Verst. norddeutsch. Kreide, p. 99, pl. 15, fig. 13.)
—— *padanum* Perconig, **301,** p. 131, pl. 2, figs. 1–2. Transition beds between upper Miocene and lower Pliocene, N. Italy.
—— *vicksburgense* Todd, **375,** p. 22, pl. 3, fig. 21. Middle Oligocene (Vicksburg), Mississippi, U.S.A.
Nonionella liebusi Hagn, **175,** p. 161, pl. 2, fig. 10. Rupelian, Bavaria, Germany.
—— *minutissima* Todd, **375,** p. 24, pl. 3, fig. 20. Middle Oligocene (Vicksburg), Mississippi, U.S.A.
Nummulites bullata Azzaroli, **25,** p. 125, pl. 10, figs. 8, 9. Eocene, Somalia.
—— *migiurtina* Azzaroli, **25,** p. 120, pl. 10, figs. 1–4. Eocene, Somalia.
OCULOSIPHON, gen. nov. Avnimelech, **23,** p. 65. New genus of the suborder Monothalamia Avnimelech 1952, ut supra; subfam. Psammosiphonellinae Avnimelech 1952, ut infra. Genotype: *Rhabdammina linearis* Brady, 1879, Quart. Jour. Micr. Science, London, n.s., vol. 19, p. 37, pl. 3, figs. 10, 11. Recent.
Orbitolites crassipora Hofker, **199,** p. 108, text fig. 56. Recent, Frederickstad, Santa Cruz.
—— *annulatus* Hofker, **199,** p. 103, text fig. 52. Recent, Buck Island, West Indies.
ORTHOMORPHINA gen. nov. Stainforth, **345,** p. 8. New genus of the family Heterohelicidae (?), subfam. Plectofrondicullariinae (?). Genotype: *Nodogenerina havanensis* Cushman and Bermudez, 1937, Contr. Cushman Lab. Foram. Res., vol. 13, p. 14, pl. 1, figs. 47, 48. Eocene to Recent.
—— *parallela* Napoli Alliata, **285,** p. 97, pl. 5, fig. 7. Pleistocene (Calabrian), N. Italy.
Osangularia brunswickensis Todd and Kniker, **378,** p. 24, pl. 4, fig. 22. Upper Eocene, Chile.
—— see also *Parrella.*
Palmula magellanica Todd and Kniker, **378,** p. 17, pl. 3, fig. 22. Upper Eocene, Chile.
PARAMILIOTIDAE new "appendice-famille" Sigal, **336,** p. 208. Comprises the genera *Miliammina* Heron-Allen and Earland, 1930; *Silicosigmolina* Cushman and Church, 1929; and *Spirolocammina* Earland, 1934. Cretaceous and Recent. (Note: The compiler doubts the validity of this family since there is, to his knowledge, no genus *Paramiliola* from which the family name could be derived.)
Parrella cheniourensis Sigal, **338,** p. 27, text fig. 27. Cenomanian, Algeria. (Note: should be assigned to the genus *Osangularia.*)
—— *cretacea* Carbonnier, **66,** p. 115, pl. 5, fig. 9. Upper Cenomanian, Morocco. (Note: should be assigned to *Osangularia.*)
PAUMOTUA gen. nov. Loeblich, **245,** p. 192. New genus of the family Rotaliidae. Genotype: *Eponides terebra* Cushman, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, p. 89, pl. 10, fig. 1. Recent, Pacific.
PENOPERCULINOIDES gen. nov. Cole and Gravell, **81,** p. 714. New genus of the family Amphisteginidae. Genotype: *Penoperculinoides cubensis* Cole and Gravell, 1952, ut infra. Middle Eocene.
—— *cubensis* Cole and Gravell, **81,** p. 714, pl. 91, figs. 9–12. Middle Eocene, Cuba.
PILEOLINA gen. nov. Bermudez, **40,** p. 38. New genus of the family Rotaliidae, subfam. Discorbisinae. Genotype: *Valvulina pileolus* Orbigny, 1839, Foram. Voy. Amér. Mérid., V, pt. 5, p. 47, pl. 1, figs. 15–17. Cretaceous to Recent.
PLANISPIRILLINA gen. nov. Bermudez, **40,** p. 26. New genus of the family Spirillinidae, subfam. Spirillininae. Genotype: *Spirillina limbata* Brady, 1879, var. *papillosa* Cushman, 1915, U. S. Nat. Mus., Bull. 71, pt. 5, p. 6, pl. 2, fig. 4. Pennsylvanian to Recent.
PLANODISCORBIS gen. nov. Bermudez, **40,** p. 40. New genus of the family Rotaliidae, subfam. Discorbisinae. Genotype: *Discorbis rarescens* Brady, 1884, Rept. Voy. *Challenger,* Zool., vol. 9, p. 651, pl. 90, figs. 2, 3. Recent.

PLANOGYPSINA gen. nov. Bermudez, **40,** p. 124. New genus of the family Planorbulinidae, subfam. Gypsininae. Genotype: *Gypsina vesicularis* (Parker and Jones, 1860) var. *squamiformis* Chapman, 1901, Jour. Linn. Soc. London, vol. 28, no. 181, p. 20, pl. 19, fig. 15. Tertiary to Recent.

Planomalina pustulosa Umiker, **388,** p. 9, pl. 4, figs. a–f; text fig. 1. Middle Cretaceous, Bernese Oberland, Switzerland.

Planulina cheniourensis Sigal, **338,** p. 20, text fig. 17. Aptian, Algeria.

—— *poronaiensis* Asano, **20,** p. 42, pl. 4, fig. 7. Oligocene, Hokkaido, Japan.

Plectina poronaiensis Asano, **20,** p. 33, pl. 4, figs. 12, 13. Oligocene, Hokkaido, Japan.

Plectofrondicularia poststriata Hagn, **175,** p. 165, pl. 2, fig. 8. Burdigalian, Bavaria, Germany.

PLECTORECURVOIDES gen. nov. Noth, **289,** p. 1. New genus of the family Lituolidae. Genotype: *Plectorecurvoides alternans* Noth, 1952, ut infra. Middle (to basal Upper?) Cretaceous.

—— *alternans* Noth, **289,** p. 1, text figs. 1, 2. Middle Cretaceous (Gault), Austria.

Pleurostomella aguafrescaensis Todd and Kniker, **378,** p. 23, pl. 4, fig. 17. Upper Eocene, Chile.

Pliolepidina see *Lepidocyclina*.

PLUMMERELLA subgen. nov. Bronnimann, **59** p. 37. New subgenus of genus *Rugoglobigerina* Bronnimann, 1952, ut infra. Family Globigerinidae. Subgenotype: *Rugoglobigerina* (*Plummerella*) *hantkeninoides* Bronnimann, ut infra. Upper Cretaceous (Maestrichtian). (Note: The subgenus name is preoccupied by *Plummerella* DeLong, 1942, Ann. Ent. Soc. America, vol. 35, p. 200, Hemidoptera. Bronnimann changed his name to *Plummerita* nom. nov. 1952, ut infra.)

Plummerella see *Rugoglobigerina*.

PLURILOCULINIDEA new suborder, Sigal, **336,** p. 160. Includes the superfamilies Lituolidea, Fusulinoidea, Miliolidea, Lagenidea, Buliminidea, Rotalidea.

Pninaella (*?*) *pulchella* F. L. Parker, **299,** p. 420, pl. 6, figs. 18–20. Recent, Atlantic, off New Hampshire, U.S.A., 29 m.

Polydiexodina crimea Tumanskaja, **384,** pp. 68–72 (no information available) Permian, Soviet Russia.

—— *polae* Tumanskaja, **384,** pp. 68–72 (no information available) Permian, Soviet Russia.

—— *vediensis* Tumanskaja, **384,** pp. 68–72 (no information available). Permian, Soviet Russia.

PORITEXTULARIA gen. nov. Loeblich and Tappan, **248,** p. 264. New genus of family Textulariidae. Genotype: *Textularia panamensis* Cushman in Lalicker and McCulloch, 1940 (not Cushman, 1918), Allan Hancock Pacific Exped., vol. 6, no. 2, p. 136, pl. 15, fig. 18 a–c. Recent.

—— *mexicana* Loeblich and Tappan, **248,** p. 264, text figs. 1–3. Recent, Pacific, off Sinaloa, Mexico, 8 fathoms. (For: *Textularia panamensis* Cushman in: Lalicker and McCulloch, 1940, see reference under *Poritextularia* gen. nov. ut supra.)

PRAEAMMOASTUTA gen. nov. Bursch, **64,** p. 915. New genus of the family Reophacidae?. subfam. Reophacinae?. Genotype: *Praeammoastuta alberdingi* Bursch, 1952, ut infra. Oligocene (probably brackish water).

—— *alberdingi* Bursch, **64,** p. 917, pl. 122, figs. 1–4; text fig. 3. Oligocene, Venezuela.

PRAEGLOBOTRUNCANA gen. nov. Bermudez, **40,** p. 52. New genus of the family Rotaliidae, subfam. Globotruncaninae. Genotype: *Globorotalia delrioensis* Plummer, 1931, Univ. Texas Bull. 3101, p. 199, pl. 13, fig. 2. Lower Cretaceous.

Proporocyclina see *Pseudophragmina*.

PSAMMOSIPHONELLA gen. nov. Avnimelech, **23,** p. 64. New genus of the suborder Monothalamia Avnimelech, 1952, ut supra, subfam. Psammosiphonellinae Avnimelech, 1952, ut infra. Genotype: *Bathysiphon arenacea* Cushman, 1927, Calif. Univ. Scripps Inst. Ocean., Bull., Tech. Ser. vol. 1, p. 129, pl. 1, fig. 2. Ordovician; Silurian; Cretaceous; Tertiary and Recent.

PSAMMOSIPHONELLINAE new subfam. Avnimelech, **23,** p. 64. New subfamily of the suborder Monothalamia Avnimelech, 1952, ut supra. Includes the genera: *Amphitremoidea* Eisenack, 1937; *Croneisella* Dunn, 1942; *Globosiphon* Avnimelech, 1952 ut supra; *Oculosiphon* Avnimelech, 1952, ut supra; and *Psammosiphonella* Avnimelech, 1952, ut supra.

Pseudoclavulina brayi Colom, **84,** p. 40, pl. 11, figs. 1–32. Upper Albian-Cenomanian, Spain.

Pseudocyclammina ammobaculitiformis Maync, **262,** p. 51. Lower and middle Sequanian, Jura Mountains, Switzerland. For: *Ammobaculites coprolithiformis* (Schwager, 1868) var. *sequana* Mohler, 1938, Schweiz. Paläont. Abh., vol. 60, p. 11, pl. 3, figs. 1–7; pl. 2, fig. 1; text fig. 8.

Pseudoglandulina radiata Barnard, **30,** p. 347, fig. A, no. 2. Oxfordian, England.

Pseudoparrella molassica Hagn, **175,** p. 180, pl. 2, fig. 13. Chattian, Bavaria, Germany.

Pseudophragmina (*Proporocyclina*) *compacta* Cole and Gravell, **81,** p. 720, pl. 95, fig. 6; pl. 99, figs. 6–8; pl. 100, figs. 1, 2, 5, 6, 13. Middle Eocene, Cuba.

—— (——) *convexicamerata* Cole and Gravell, **81,** p. 721, pl. 101, figs. 1–3; pl. 102, figs. 12–19. Middle Eocene, Cuba.

—— (——) *penonensis* Cole and Gravell, **81,** p. 723, pl. 103, figs. 2–9. Middle Eocene, Cuba.

—— (——) *teres* Cole and Gravell, **81,** p. 725, pl. 100, figs. 3, 10–12, 14; pl. 101, figs. 6–8. Middle Eocene, Cuba.

Pyrgo hachijensis Uchio, **386,** p. 151, pl. 6, fig. 1. Recent, Japan.

Pyrulina aequalis Todd, **375,** p. 19, pl. 3, fig. 10. Middle Oligocene (Vicksburg), Mississippi, U.S.A.

—— *infracretacea* Bartenstein, **33,** p. 311, text fig. 5. Middle Barremian, N.W. Germany.

Quinqueloculina frigida F. L. Parker, **299,** p. 406, pl. 3, fig. 20. Recent, Atlantic, off New Hampshire, U.S.A.

—— *fulgida* Todd, **375,** p. 7, pl. 1, fig. 18. Middle Oligocene (Vicksburg), Mississippi, U.S.A.

Ranikothalia sahnii L. M. Davies, **104,** p. 156, pl. 1, figs. 1, 4, 5. Paleocene, Dahomey, Togoland, West Africa.

—— *savitriae* L. M. Davies, **104,** p. 156, pl. 1, figs. 3, 6, 9, 10. Paleocene, Dahomey, Togoland, West Africa.
Rectobolivina marentinensis Ruscelli, **327,** p. 46, pl. 2, fig. 8. Tortonian, Italy.
Reinholdella brandi Hofker, **200,** p. 23, text fig. 11. Dogger ϵ, N.W. Germany.
—— *epistominoides* Hofker, **200,** p. 29, text fig. 17. Dogger, N.W. Germany.
—— *ornata* Hofker, **200,** p. 24, text figs. 12–16. Dogger ϵ, N.W. Germany.
—— *pachyderma* Hofker, **200,** p. 16, text figs. 1, 2. Upper Liassic, Luxembourg.
Reussella checchia-rispolii Kicinski, **223,** p. 34, pl. 2, figs. 3–5. Lower Pleistocene (Calabrian), Italy.
Robulus dispansus Bandy, **27,** p. 19, pl. 5, fig. 3. Miocene, Pacific, Erben Bank (submarine).
—— *erbenensis* Bandy, **27,** p. 15, pl. 5, fig. 4. Miocene (submarine), Erben Bank, Pacific.
—— *indistincta* McLean, **266,** p. 5, pl. 1, fig. 13. Paleocene, New Jersey, U.S.A.
ROLSHAUSENIA gen. nov. Bermudez, **40,** p. 63. New genus of the family Rotaliidae, subfam. Epistomininae. Genotype: *Rotalia rolshauseni* Cushman and Bermudez, 1946, Cushman Lab. Foram. Res., Contr., vol. 22, p. 119, pl. 19, figs. 11–13. Miocene (?) to Recent.
Rotalia beccarii (Linnaeus, 1758) subsp. *hatatatensis* Takayanagi, **355,** p. 63, text fig. 5. Miocene, Japan.
—— *eponidoides* Napoli Alliata, **285,** p. 104, pl. 5, fig. 5. Upper Pliocene, Astian, N. Italy.
—— *incisura* Todd, **375,** p. 39, pl. 5, fig. 25. Middle Oligocene (Vicksburg), Mississippi, U.S.A.
—— *sigali* Drooger, **113,** p. 99, pl. 15, figs. 36, 37. Dano-Montian, Algeria.
—— *yubariensis* Asano, **21,** p. 49, pl. 6, figs. 1, 2. Miocene, Hokkaido, Japan. (Note: erroneously spelled *yubarieneis.*)
RUGOGLOBIGERINA gen. nov. Bronnimann, **59,** p. 16. New genus of the family Globigerinidae. Genotype: *Globigerina rugosa* Plummer, 1926, Univ. Texas Bull. 2644, p. 38, pl. 2, fig. 10. Turonian to Maestrichtian.
RUGOGLOBIGERINA subgenus nov. Bronnimann, **59,** p. 17. New subgenus of genus *Rugoglobigerina* Bronnimann, 1952, ut supra. Same genotype as the genus. Family Globigerinidae. Turonian to Maestrichtian.
—— (*Plummerella*) *hantkenoides* Bronnimann 1952, subsp. *costata* Bronnimann, **59,** p. 39, pl. 3, figs. 4–6; text fig. 18. Upper Maestrichtian, Trinidad. (Note: subgenus name changed to *Plummerita.*)
—— (——) —— —— subsp. *hantkenoides* Bronnimann, **59,** p. 37, pl. 3, figs. 1–3; text fig. 17. Upper Maestrichtian, Trinidad.
—— (——) —— —— subsp. *inflata* Bronnimann, **59,** p. 40, pl. 3, figs. 7–9; text fig. 19. Upper Maestrichtian, Trinidad.
—— (*Rugoglobigerina*) *macrocephala* Bronnimann, 1952, subsp. *macrocephala* Bronnimann, **59,** p. 25, pl. 2, figs. 1–3; text fig. 9. Turonian to Maestrichtian, Trinidad.
—— (——) —— —— subsp. *ornata* Bronnimann, p. 27, pl. 2, figs. 4–6; text fig. 10. Top Senonian and Maestrichtian, Trinidad.
—— (——) *reicheli* Bronnimann, 1952, subsp. *hexacamerata* Bronnimann, **59,** p. 23, pl. 2, figs. 10–12; text fig. 8. Maestrichtian, Trinidad.
—— (——) —— —— subsp. *pustulata* Bronnimann, **59,** p. 20, pl. 2, figs. 7–9; text figs. 6, 7. Upper Maestrichtian, Trinidad.
—— (——) —— —— subsp. *reicheli* Bronnimann, **59,** p. 18, pl. 3, figs. 10–12; text figs. 4. 5. Upper Maestrichtian, Trinidad.
—— (——) *rugosa* (Plummer, 1926) subsp. *pennyi* Bronnimann, **59,** p. 34, pl. 4, figs. 1–3; text fig. 14. Maestrichtian, Trinidad.
—— (——) —— (——) subsp. *rotundata* Bronnimann, **59,** p. 34, pl. 4, figs. 7–9; text figs. 15, 16. Maestrichtian, Trinidad.
Saracenaria see *Lenticulina.*
Saudia labyrinthica Grimsdale, **165,** p. 230, pl. 21, figs. 1–4; pl. 22, figs. 1, 2. Paleocene, Iraq.
Schackoina cabri Sigal, **328,** p. 20, text fig. 18. Aptian, Algeria.
SCHLUMBERGERELLA gen. nov. Hanzawa, **180,** p. 19. New genus of the family Planorbulinidae. Genotype: *Baculogypsina floresiana* Schlumberger, 1896, Mém. Soc. Zool. France, vol. 9, p. 88, pl. 3, figs. 1–3; pl. 4, fig. 7. Pleistocene to Recent.
Sigmomorphina chileana Todd and Kniker, **378,** p. 18, pl. 3, fig. 25. Upper Eocene, Chile.
—— *pulchra* Todd, **375,** p. 20, pl. 3, fig. 13. Middle Oligocene (Vicksburg), Mississippi, U.S.A.
SILVESTRIELLA gen. nov. Hanzawa, **180,** p. 17. New genus of the family Planorbulinidae. Genotype: *Calcarina tetraedra* Gümbel, 1868 (1870), Abhandl. math.-phys. Cl. k. Bayer. Akad. Wiss. München, vol. 10, p. 656, pl. 2, fig. 97. Upper Eocene (Auversian to Bartonian). (Cave: *Silvestrella* Escherich, 1905, Thyasanura, and *Silvestriellus* Brethes 1910, Diptera.)
Sinzowella variabilis Y. LeCalvez, **236,** p. 33, pl. 3, figs. 36, 37. Lutetian, Paris Basin, France.
Siphogaudryina see *Gaudryina.*
Siphonodosaria chileana Todd and Kniker, **378,** p. 23, pl. 3, figs. 31, 32. Upper Eocene, Chile.
—— *longae* McLean, **266,** p. 10, pl. 2, figs. 17–20. Paleocene, New Jersey, U.S.A.
Spirolina cylindracea Lamarck, 1804, var. *glabra* Y. LeCalvez, **236,** p. 22, pl. 2, figs. 13, 14. Lutetian, Paris Basin, France.
—— *mariei* Y. LeCalvez, **236,** p. 25, pl. 2, figs. 17, 18. Lutetian, Paris Basin, France.
Spiroplectammina brunswickensis Todd and Kniker, **378,** p. 6, pl. 1, fig. 16. Upper Eocene, Chile.
—— *elgansoensis* Todd and Kniker, **378,** p. 7, pl. 1, fig. 17. Upper Eocene, Chile.
—— *gandolfii* Carbonnier, **66,** p. 112, pl. 5, fig. 2. Upper Cenomanian, Morocco.
—— *niigataensis* Asano and Inomata, **22,** p. 4, figs. 15–17. Miocene, Japan.
TAWITAWIA gen nov. Loeblich, **245,** p. 190. New genus of the family Textulariidae. Genotype: *Textularia immensa* Cushman, 1921, U. S. Nat. Mus. Bull. 100, vol. 4, p. 118, pl. 24, fig. 4. Recent (Pacific). (Note: Cushman

published his species in 1913, U. S. Nat. Mus. Proc., vol. 44, p. 633, pl. 79, fig. 2.)

TESTULORHIZA gen. nov. Avnimelech, **23,** p. 66. New genus of the suborder Monothalamia Avnimelech, 1952, ut supra, subfam. Testulosiphoninae Avnimelech, 1952, ut infra. Genotype: *Rhizammina globigerinifera* Hofker, 1930, Foram. Siboga Exped., pt. 2, Monogr 4a, p. 117, pl. 51, fig. 2. Recent.

TESTULOSIPHON gen. nov. Avnimelech, **23,** p. 66. New genus of the suborder Monothalamia Avnimelech, 1952, ut supra, subfam. Testulosiphoninae Avnimelech 1952, ut infra. Genotype: *Rhizammina indivisa* Brady, 1884, Rept. Voy. *Challenger*, Zool., vol. 9, p. 277, pl. 29, figs. 5–7. Recent.

TESTULOSIPHONINAE new subfam. Avnimelech, **23,** p. 66. Includes the genera: *Testulorhiza* Avnimelech, 1952, ut supra, and *Testulosiphon* Avnimelech, 1952, ut supra. Recent.

Textularia magallanica Todd and Kniker, **378,** p. 7, pl. 1, figs. 20, 21. Upper Eocene, Chile.

—— *pitmani* McLean, **266,** p. 3, pl. 3, figs. 7, 10. Paleocene, New Jersey, U.S.A.

—— *richardsi* McLean, **266,** p. 3, pl. 1, figs. 1–6. Paleocene, New Jersey, U.S.A.

—— *torquata* F. L. Parker, **299,** p. 403, pl. 3, figs. 9–11. Recent, Atlantic, off New Hampshire, U.S.A.

—— *vincentownensis* McLean, **266,** p. 4, pl. 3, figs. 1–5. Paleocene, New Jersey, U.S.A.

THALMANNITA gen. nov. Bermudez, **40,** p. 76. New genus of the family Rotaliidae, subfam. Rotaliinae. Genotype: *Rotalia madrugaensis* Cushman and Bermudez, 1947, Cushman Lab. Foram. Res., Contr., vol. 23, p. 24, pl. 5, fig. 4. Paleocene to Oligocene.

Thurammina tendami Bartenstein, **33,** p. 307. Upper Barremian, N.W. Germany. For: *Thurammina* D3 Hecht, 1938, Senckenberg. Naturf. Ges. Abhandl., No. 443, pl. 9, b, figs. 37–38; pl. 24, figs. 120–122.

Triloculina architectura Todd, **375,** p. 10, pl. 1, fig. 33. Middle Oligocene (Vicksburg), Mississippi, U.S.A.

TRINITELLA gen. nov. Bronnimann, **59,** p. 56. New genus of the family Globigerinidae. Genotype: *Trinitella scotti* Bronnimann, 1952, ut infra. Upper Cretaceous (Maestrichtian).

—— *scotti* Bronnimann, **59,** p. 57, pl. 4, figs. 4–6; text fig. 30. Maestrichtian, Trinidad.

Triplasia bartensteini Loeblich and Tappan, **250,** p. 8, pl. 1, fig. 9. Dogger, N.W. Germany.

—— *deadericki* Loeblich and Tappan, **250,** p. 35, pl. 6, figs. 1–5. Senonian, Arkansas, U.S.A.

—— *glenrosensis* Loeblich and Tappan, **250,** p. 17, pl. 2, figs. 7–13. Aptian, Texas, U.S.A.

—— *kingakensis* Loeblich and Tappan, **250,** p. 7, pl. 1, figs. 1–8. Liassic, Alaska.

—— *marwicki* Loeblich and Tappan, **250,** p. 46, pl. 8, figs. 2–4. Miocene, New Zealand.

—— *mexicana* Loeblich and Tappan, **250,** p. 15, pl. 2, figs. 21, 22. Hauterivian, Mexico.

—— *nodosa* Loeblich and Tappan, **250,** p. 25, pl. 5, figs. 8–15. Cenomanian, Oklahoma, U.S.A.

—— *plummerae* Loeblich and Tappan, **250,** p. 36, pl. 6, figs. 14–19. Upper Cretaceous, Texas, U.S.A.

—— *saratogensis* Loeblich and Tappan, **250,** p. 41, pl. 7, figs. 10, 11. Maestrichtian, Arkansas, U.S.A.

Tristix carinata Sigal, **338,** p. 17, text fig. 11. Barremian, Algeria.

—— *comalensis* Loeblich and Tappan, **249,** p. 360, text figs. 5–7. Lower Cretaceous, Texas, U.S.A.

—— *djaffaensis* Sigal, **338,** p. 14, text fig. 6. Hauterivian, Algeria.

Trochamminella atlantica F. L. Parker, **299,** p. 409, pl. 4, figs. 17–19. Recent, Atlantic, off Melville Sound, Canada, 124 m.

UNILOCULINIDEA new suborder Sigal, **336,** p. 154. Comprises the superfamilies Lagynidea and Astrorhizidea.

Uvigerina finisterrensis Colom, **84,** p. 27, pl. 4, figs. 1, 2, 13, 14; text fig. 4. Recent, off Spain (Galicia), 300–600 m.

Vaginulina procera Albers, **5,** p. 80, pl. 4, figs. 1–4; text figs. 4–9. Barremian, N.W. Germany.

—— *strigillata* (Reuss, 1845) subsp. *bettenstaedti* Albers, **5,** p. 93, pl. 4, fig. 7; text figs. 22, 23. Barremian, N.W. Germany.

—— *weigelti* Bettenstaedt, **44,** p. 274, pl. 2, figs. 22–25. Upper Barremian, N.W. Germany.

Vaginulinopsis pseudodecorata Hagn, **175,** p. 146, pl. 1, fig. 5. Rupelian, Bavaria, Germany.

Valvulina angulosa Y. LeCalvez, **236,** p. 12, pl. 1, fig. 3. Lutetian, Paris Basin, France.

—— *cribrobuliminoides* Y. LeCalvez, **236,** p. 13, pl. 1, fig. 5. Lutetian, Paris Basin, France.

—— *guillaumei* Y. LeCalvez, **236,** p. 13, pl. 1, Lutetian, Paris Basin, France.

—— *triedra* Y. LeCalvez, **236,** p. 14, pl. 1, fig. 2. Lutetian, Paris Basin, France.

Valvulineria fabianii Kicinski, **223,** p. 36, pl. 3, fig. 8. Lower Pleistocene (Calabrian), Italy.

—— *koenigswaldi* Drooger, **113,** p. 98, pl. 15, figs. 32, 33. Dano-Montian, Algeria.

—— *palmi* Drooger, **113,** p. 98, pl. 15, figs. 34, 35. Dano-Montian, Algeria.

Ventilabrella see *Gümbelina.*

Verneuilinoides subfiliformis Bartenstein, **33,** p. 308, text figs. 2, 3. Upper Barremian, N.W. Germany.

Virgulina cruysi Drooger, **113,** p. 96, pl. 15, figs. 25, 26. Dano-Montian, Algeria.

—— —— —— var. *maadidensis* Drooger, **113,** p. 97, pl. 15, figs. 27, 28. Dano-Montian, Algeria.

—— *troosteri* Drooger, **113,** p. 95, pl. 15, figs. 23, 24. Dano-Montian, Algeria.

NOMINA NOVA IN 1952

Allomorphina fragilis nom. nov. Hofker in Thalmann, **367,** p. 14. Recent Indonesia. New name for: *Allomorphina pacifica* Hofker, 1951, non Cushman and Todd, 1949.

AMMOPEMPHIX nom. nov. Loeblich, **244,** p. 82. Recent, Antarctic and Arctic; Miocene. For *Urnula* Wiesner, 1931, non Claparède and Lachmann, 1857. Genotype of *Ammopemphix* is *Urnula quadrupla* Wiesner, 1931, Deutsche Südpolar-Exped., vol. 20, Zool., p. 83, pl. 6, figs. 56, 57.

Anomalinoides barleeanum (Williamson, 1858) var. *zandamae* nom. nov. Voorthuysen, **394,** p. 681. Pleistocene, The Netherlands. New name for: *Nonion barleeanum* (Williamson, 1858) var. *inflatum* Voorthuysen, 1950 (later assigned to the genus *Anomalinoides*), non *Nonionina inflata* Alth, 1850.

Bolivina ordinaria nom. nov. Phleger and F. L. Parker, in Thalmann, **367,** p. 14. Recent, N.W. Gulf of Mexico. New name for: *Bolivina simplex* Phleger and F. L. Parker, 1951, non *Bolivina interjuncta* Cushman var. *simplex* Cushman and Renz, 1941.

Cassidulina islandica Nörvang, 1945, var. *nörvangi* nom. nov. Thalmann in Phleger, **309,** p. 83, footnote 1. Recent, off Iceland. New name for *Cassidulina islandica* Norvang 1945 var. *minuta* Norvang, 1945, non *Cassidulina minuta* Cushman, 1933.

Cibicides corpulentus nom. nov. Phleger and F. L. Parker, in Thalmann, **367,** p. 14. Recent, N.W. Gulf of Mexico. New name for *Cibicides robustus* Phleger and F. L. Parker, 1951, non LeCalvez, 1949.

CONORBOIDES nom. nov. Hofker in Thalmann, **367,** p. 14. Lower Cretaceous. New name for *Conorbis* Hofker, 1951, non Swainson, 1840.

Cornuspira ? subprimitiva nom. nov. Bartenstein and Brand, **35,** p. 342. Lower Cretaceous, Germany. New name for *Cornuspira primitiva* Bartenstein and Brand, 1951, non Rhumbler 1903.

Cyclammina schuberti nom. nov. Hagn, **175,** p. 136. Upper Oligocene, Bavaria. New name for *Cyclammina gracilis* Schubert, 1904, non Grzybowski, 1901.

Frondicularia inaequalis Costa, 1857 var. *silvestriana* nom. nov. Thalmann, **366,** p. 983. Pliocene, Italy. New name for *Frondicularia inaequalis* Costa, 1857 var. *costata* Silvestri, 1896, non *Frondicularia costata* Kübler and Zwingli, 1866.

—— *surfibrata* nom. nov. Harris and Jobe, **182,** p. 144. Paleocene, Arkansas. New name for *Frondicularia frankei* Cushman, 1936, var. *costata* Harris and Jobe, 1951, non *Frondicularia costata* Kübler and Zwingli, 1866.

Lagena terquemi nom. nov. Y. LeCalvez, **236,** p. 38, pl. 4, fig. 45. Lutetian, Paris Basin, France. New name for *Lagena histrix* Terquem 1882, Mém. Soc. géol. France (3), vol. 2, p. 28, pl. 1, fig. 14.

Lituola westfalica nom. nov. Bartenstein, **34,** p. 323, pl. 1, figs. 5, 6, 14; pl. 5, figs. 1–6. Upper Campanian, Westphalia, Germany. New name for *Haplophragmium aequale* Roemer sp. in: Reuss, 1860, Sitzber. Akad. Wiss. Wien, vol. 50, p. 218, pl. 11, figs. 2, 3. (Note: for the new subspecies *westfalica* and *hannoverana* see preceding Index for 1952.)

Loxostomum abruptum nom. nov. Phleger and F. L. Parker in Thalmann, **367,** p. 14. Recent. N.W. Gulf of Mexico. New name for *Loxostomum truncatum* Phleger and F. L. Parker, 1951, non Finlay, 1947.

Marginulina nuttalli nom. nov. Todd and Kniker, **378,** p. 14, pl. 2, figs. 30, 31. Upper Eocene, Chile. New name for: *Cristellaria sublituus* Nuttall, 1932 (non *Marginulina sublituus* Orbigny 1826), Jour. Paleontology, vol. 6, p. 11, pl. 1, figs. 13, 14.

Nummulites budensis Hantken, 1875, var. *silvestriana* nom. nov. Thalmann, **366,** p. 983. Eocene, Somalia. New name for *Nummulites budensis* Hantken, 1875, var. *crassa* Silvestri, 1942, non *Nummulina crassa* Boubée, 1833.

—— *discorbina* (Schlotheim, 1820) var. *rozloszniki* nom. nov. Thalmann, **366,** p. 983. Eocene, South Arabia. New name for *Nummulina discorbina* (Schlotheim, 1820) var. *major* Rozloszniк, 1929, non *Nummulina* (*Paronaea*) *wemmelensis* de la Harpe and van den Broeck var. *major* Grönwald, 1927.

PLUMMERITA nom. nov. Bronnimann, **58,** p. 146. Upper Cretaceous. New subgenus name of the genus *Rugoglobigerina* Bronnimann, 1952 (see Index, ut supra) for *Plummerella* Bronnimann, 1952, ut supra, preoccupied by *Plummerella* DeLong, 1942, a hemidopteran genus.

Polymorphina undacuneata nom. nov. Harris and Jobe, **182,** p. 145, Paleocene, Arkansas, U.S.A. New name for *Polymorphina palmaris* Harris and Jobe, 1951 var. *parallela* Harris and Jobe, 1951, non *Polymorphina regularis* Münster, 1838 var. *parallela* Millett, 1895.

Psammosiphonella coalingensis nom. nov. Avnimelech, **23,** p. 65. Eocene, California, U.S.A. New name for *Rhabdammina eocenica* Cushman and G. D. Hanna, 1927, Proc. Calif. Acad. Sci., (4), vol. 16, p. 209, pl. 13, fig. 1.

Reophax hempsteadensis nom. nov. Harris and Jobe, **182,** p. 145. Paleocene, Arkansas, U.S.A. New name for *Reophax sabulosus* Harris and Jobe, 1951, non Brady, 1881.

—— *neominutissima* nom. nov. Bartenstein and Brand, **35,** p. 342. Lower Cretaceous, Germany. New name for *Reophax minutissima* Bartenstein and Brand, 1951, non Plummer, 1945.

Schenckiella exigua nom. nov. Hofker in Thalmann, **367,** p. 14. Recent, Indonesia. New name for *Listerella* (now *Schenckiella*) *minuta* Hofker, 1951, non *Listerella* (now *Schenckiella*) *minuta* Hussey, 1949.

Textularia earlandi nom. nov. F. L. Parker, **300,** p. 106, footnote. New name for *Textularia tenuissima* Earland, 1933, non Häusler, 1881. Recent, Arctic.

Vaginulina riedeli Bartenstein and Brand, 1951, subsp. *delicatocostata* nom. nov. Bartenstein and Brand, **35,** p. 342. Lower Cretaceous, Germany. New name for *Vaginulina riedeli paucicostata* Bartenstein and Brand, 1951, non *Vaginulina paucicostata* Reuss, 1863.

Valvulina terquemi nom. nov. Y. LeCalvez, **236** p. 14, pl. 1, fig. 6. Lutetian, Paris Basin, France. New name for *Textilaria spinigera* Terquem, 1882, Mém. Soc. géol. France (3), vol. 2, p. 146, pl. 15, fig. 13.

HOMONYMS IN 1952

Bulimina tenuis Napoli Alliata, **285,** p. 100, pl. 5, figs. 4, 6. Pleistocene, Italy, preoccupied by Phleger and F. L. Parker, 1951, Geol. Soc.

America, Mem. 46, pt. 2, p. 16, pl. 7, figs. 33, 34, Recent, Gulf of Mexico.

Gaudryina inflata Carbonnier, **66,** p. 112, pl. 5, fig. 1, Cenomanian, Morocco, preoccupied by *Gaudryina* (*Gaudryina*) *inflata* Israelsky, 1951, U. S. Geol. Surv. Prof. Pap. 240–A, p. 16, pl. 6, figs. 1–12, Paleocene-Eocene, California; Renamed: *Gaudryina tazaensis* nom. nov. Carbonnier, 1953, Soc. géol. France, Comptes rendus, p. 20.

Marginulina bachei Bailey, 1851, var. *africana* Marks, **259,** p. 286, pl. 1, figs. 6–8, Miocene, Algeria, preoccupied by *Marginulina africana* Muraour, 1949, Bull. Carte géol. Algérie, (1), Paléont. No. 10, pt. 2, p. 109, pl. 2 figs. 22, 23, lower Pliocene, Algeria.

Nonion compressum Napoli Alliata, **285,** p. 96, pl. 5, fig. 2, Pleistocene, Italy, preoccupied by *Nonionina compressa* Roemer, 1841, Verst. norddeutsch. Kreide, p. 999, pl. 15, fig. 33, Cretaceous, Germany.

Plummerella Bronnimann, **59,** p. 37, Maestrichtian subgenus of *Rugoglobigerina* Bronniman, 1952, ut supra, preoccupied by *Plummerella* (also *Plumerella*) DeLong, 1942, Ann. Entom. Soc. America, vol. 35, p. 200, a hemidopteran genus. Renamed: *Plummerita* nom. nov. Bronnimann, **58,** p. 148.

NOMINA NUDA 1952

The following nomina nuda were encountered in the literature on the Foraminifera for the year 1952:

In: Deleau, **107,** p. 28: *Pseudocuneolina* from the Barremian of Algeria.

In: Durand Delga and Sigal, **119,** p. 116: *Globorotalia spinuloinflata,* n. sp., from the Algerian Eocene; the same nomen nudum is also found in Durand Delga, **116,** p. 31.

In the Japanese text of Kanmera, **217,** p. 20 and 22: *Fusulina higoensis, F. ohtanii, F. gracilis; Pseudoschwagerina minatoi, P. shimodakensis; Quasifuslina kurikiensis; Triticites matsumotoi, T. yayamadakensis;* and *Wedekindellina* (*?*) *prolifica,* all from the Upper Carboniferous and Permian of Japan.

In: Repal, **318,** p. 19: *Ehrenbergina simplissima,* n. sp., Dam and Magné and in: Sigal, **338,** p. 13: *Flabellammina gracilis,* n. sp., *Buccicrenata inflata,* n. sp., *Valvulina tidefti,* n. sp., *Verneuilina tritaxioides,* n. sp. *Neobulimina algeriana,* n. sp., all from the Algerian Hauterivian; and *Globotruncana angusticarinata* Gandolfi mut. "*praefornicata*" n. sp. and *G. sigali* Reichel mut. "*praesturti*" from the Algerian Upper Cretaceous.

FORMS WITH NOMENCLATURA APERTA 1952

Acerroschwagerina ? sp. Toriyama, **381,** p. 141, pl. 4, fig. 4. Permian, Japan.

Alveolina sp. Favre, **137,** pl. 1, fig. 12. Eocene, Switzerland.

Ammobaculites sp. Asano, **20,** p. 32, pl. 4, fig. 9. Oligocene, Hokkaido.

Amphimorphina sp. Todd, **375,** p. 25, pl. 4, fig. 4. Middle Oligocene, Mississippi.

Anomalina sp. Schuh, **333,** p. 344, pl. A, figs. 17, 18. Eocene, Germany.

Asterocyclina sp. Favre, **137,** pl. 1, fig. 10. Eocene, Switzerland.

Bolivina sp. Crouch, **95,** pl. 3, fig. 11. Recent, off California.

Bulimina sp. Todd, **375,** p. 27, pl. 4, fig. 13. Middle Oligocene, Mississippi.

Cassidulina sp. Asano, **21,** p. 50, pl. 6, fig. 4. Miocene, Hokkaido.

Cassidulinoides sp. A Crouch, **95,** pl. 6, fig. 17. Recent, off California.

—— sp. B Crouch, **95,** pl. 6, fig. 18. Recent, off California.

Ceratobulimina sp. Todd and Kniker, **378,** p. 24, pl. 4, fig. 23. Upper Eocene, Chile.

Cribrogenerina ? sp. Azzaroli, **25,** pl. 11, fig. 10. Eocene, Somalia.

Cristellaria sp. Johannsen, **212,** pl. 12, fig. 4. Middle Senonian, Germany.

—— sp. Johannsen, **212,** pl. 12, fig. 5. Upper Senonian, Germany.

—— sp. Johannsen, **212,** pl. 12, fig. 6. Lower Senonian, Germany.

—— sp. Johannsen, **212,** pl. 12, fig. 7. Lower Senonian, Germany.

—— sp. Johannsen, **212,** pl. 13, fig. 5. Lower Senonian, Germany.

—— sp. Johannsen, **212,** pl. 13, fig. 19. Upper Senonian, Germany.

Dendritina sp. Azzaroli, **25,** pl. 5, fig. 3. Eocene, Somalia.

Dentalina sp. Barnard, **30,** p. 346, pl. A, fig. 8. Oxfordian, England.

—— sp. Colom, **84,** p. 22, pl. 5, fig. 29. Recent, off Spain.

—— sp. Colom, **86,** p. 70, pl. 5, fig. 3. Upper Cretaceous, Spain.

—— sp. Crouch, **95,** pl. 1, figs. 8, 9. Recent, off California.

Discorbis sp. Wicher, **405,** p. 260, text fig. 2, nos. 1, 2. Lower Cretaceous, Yugoslavia.

—— sp. Wicher, **405,** p. 260, text fig. 2, nos. 3, 4. Lower Cretaceous, Yugoslavia.

Dorothia sp. Asano, **20,** p. 33, pl. 4, fig. 10. Oligocene, Hokkaido.

Elphidium sp. Asano, **21,** p. 48, pl. 4, fig. 8. Miocene, Hokkaido.

Endothyra sp. Wray, **407,** p. 948, text figs. 15–19. Mississippian, West Virginia.

Endothyra ? sp. ? Wray, **407,** p. 948, text fig. ?. Mississippian, West Virginia.

—— sp. ? Wray, **407,** p. 948, text fig. 13. Mississippian, West Virginia.

Eponides sp. A Crouch, **95,** pl. 5, figs. 10, 11. Recent, off California.

Gaudryina (*Siphogaudryina*) sp. Carbonnier, **66,** p. 113, pl. 5, fig. 4. Upper Cenomanian, Morocco.

Globigerina n. sp. Bronnimann, **60,** p. 21, pl. 3, figs. 4–6. Lower Eocene, Trinidad.

—— sp. A Todd, **375,** p. 43, pl. 6, fig. 9. Middle Oligocene, Mississippi.

—— sp. B Todd, **375,** p. 43, pl. 6, fig. 7. Middle Oligocene, Mississippi.

Globotruncana sp. indet. Favre, **137,** pl. 1, fig. 9. Upper Cretaceous, Switzerland.

Haplophragmoides sp. Colom, **86,** p. 80, pl. 10, fig. 23. Upper Cretaceous, Spain.

Heterostegina costata Orbigny n. sp. Papp and

Küpper, **298,** p. 3, text fig. 4. Tortonian, Vienna Basin, Austria.
—— sp. Papp and Küpper, **298,** p. 3, text fig. 2. Tortonian, Vienna Basin, Austria.
Hormosina sp. F. L. Parker, **299,** p. 395, pl. 1, figs. 8, 9. Recent, off New Hampshire.
Lenticulina sp. (n. sp. ?) Bartenstein, **33,** p. 310, text fig. 4. Upper Barremian, Germany.
—— (*Saracenaria*) sp. A Bettenstaedt, **44,** p. 273, pl. 2, fig. 15. Upper Hauterivian, Germany.
Lepidolina ? sp. A Toriyama, **381,** p. 150, pl. 6, fig. 4. Permian, Japan.
—— sp. B Toriyama, **381,** p. 152, pl. 6, fig. 5; pl. 7, fig. 1. Permian, Japan.
—— sp. C Toriyama, **381,** p. 153, pl. 7, figs. 2–5. Permian, Japan.
—— sp. D Toriyama, **381,** p. 154, pl. 7, fig. 6. Permian, Japan.
Leptodermella sp. Rottgardt, **323,** p. 175, text fig. 5. Recent, brackish-water, Slesvig-Holstein.
Lingulina sp. Uchio, **386,** p. 152, pl. 6, fig. 5. Recent, off Japan.
Lituola sp. Bartenstein, **34,** p. 324, pl. 1, fig. 16; pl. 5, fig. 7. Lower Campanian, Germany.
Marginulina sp. Todd, **375,** p. 11, pl. 2, fig. 5. Middle Oligocene, Mississippi.
—— sp. Todd and Kniker, **378,** p. 15, pl. 2, fig. 35. Upper Eocene, Chile.
Miliolinella sp. Todd and Kniker, **378,** p. 13, pl. 2, fig. 15. Upper Eocene, Chile.
Millerella sp. A Kanmera, **216,** p. 173, pl. 10, figs. 11–15. Lower Carboniferous, Japan.
—— *?* sp. B Kanmera, **216,** p. 174, pl. 12, figs. 15–17. Lower Carboniferous, Japan.
Nipponitella sp. Toriyama, **381,** p. 134, pl. 3, fig. 5. Permian, Japan.
Nodosarella ? sp. Todd and Kniker, **378,** p. 23, pl. 4, fig. 18. Upper Eocene, Chile.
Nodosaria sp. A Asano, **20,** p. 38, pl. 3, figs. 15, 16. Oligocene, Hokkaido.
—— sp. B Asano, **20,** p. 33, pl. 4, fig. 2. Oligocene, Hokkaido.
Nonionella sp. Todd and Kniker, **378,** p. 18, pl. 3, fig. 33. Upper Eocene, Chile.
Nummulites sp. Favre, **137,** pl. 1, fig. 14. Eocene, Switzerland.
Operculina sp. Papp and Küpper, **298,** p. 2, text fig. 1. Tortonian, Austria.
Parafusulina sp. Toriyama, **381,** p. 145, pl. 5, fig. 5. Permian, Japan.
Pentellina sp. Azzaroli, **25,** pl. 6, fig. 3. Eocene, Somalia.
Planularia sp. Colom, **86,** p. 27, pl. 5, fig. 17. Upper Cretaceous, Spain.
Plectogyra sp. Wray, **407,** p. 948, text figs. 1, 3, 5. Mississippian, West Virginia.
—— sp. Wray, **407,** p. 948, text fig. 4. Mississippian, West Virginia.
—— sp. Wray, **407,** p. 948, text figs. 6, 8, 9. Mississippian, West Virginia.
—— sp. Wray, **407,** p. 948, text fig. 7. Mississippian, West Virginia.
—— sp. Wray, **407,** p. 948, text figs. 10, 11. Mississippian, West Virginia.
—— sp. Wray, **407,** p. 948, text figs. 12, 14. Mississippian, West Virginia.
Proteonina sp. A F. L. Parker, **300,** p. 455, pl. 1, fig. 6, Recent, off Long Island.
—— sp. B F. L. Parker, **300,** p. 455, pl. 1, fig. 7. Recent, off Long Island.
Pseudodoliolina ? sp. Toriyama, **381,** p. 149, pl. 6, fig. 2. Permian, Japan.
Pseudofusulina ? sp. Toriyama, **381,** p. 148, pl. 6, fig. 1. Permian, Japan.
Pseudoglandulina sp. Todd, **375,** p. 14, pl. 2, fig. 16. Middle Oligocene, Mississippi.
Pseudoparrella sp. A Crouch, **95,** pl. 6, figs. 4, 5. Recent, off California.
Pseudoschwagerina ? sp. Toriyama, **381,** p. 140, pl. 4, fig. 3. Permian, Japan.
Pseudovalvulineria ? sp. Carbonnier, **66,** p. 114, pl. 5, fig. 7. Upper Cenomanian, Morocco.
Pyrgo sp. Todd and Kniker, **378,** p. 13, pl. 2, fig. 16. Upper Eocene, Chile.
Pyrulina sp. Todd and Kniker, **378,** p. 17, pl. 3, fig. 27, Upper Eocene, Chile.
Quinqueloculina sp. Asano, **21,** p. 48, pl. 6, fig. 6. Miocene, Hokkaido.
Rhapydionina sp. Azzaroli, **25,** pl. 6, fig. 3. Eocene, Somalia.
Rhizammina sp. Usbeck, **389,** p. 380, pl. 14, fig. 1. Lower Liassic, Germany.
Schwagerina ? sp. A Toriyama, **381,** p. 138, pl. 3, fig. 12. Permian, Japan.
—— *?* sp. B Toriyama, **381,** p. 139, pl. 4, figs. 1, 2. Permian, Japan.
Staffella or *Nankinella* (*?*) sp. Konishi, **226,** p. 157, pl. 14, fig. 8. Permian, Japan.
Tolypammina sp. Barnard, **30,** p. 338, pl. A, fig. 5. Oxfordian, England.
Triplasia species Loeblich and Tappan, **250,** p. 42, pl. 7, fig. 12. Paleocene-Eocene, California.
Trochammina ? sp. Todd and Kniker, **378,** p. 13, pl. 2, fig. 19. Upper Eocene, Chile.
Trocholina sp. Wicher, **405,** p. 268, text figs. 3, 5. Lower Cretaceous, Germany.
"Truncatulina" sp. Schuh, **333,** p. 344, pl. A, fig. 19. Eocene, Germany.
Uvigerina sp. Schuh, **333,** p. 342, pl. A, figs. 11, 12. Eocene, Germany.
—— sp. Todd, **375,** p. 33, pl. 4, fig. 42. Middle Oligocene, Mississippi.
Vaginulina sp. Colom, **86,** p. 72, pl. 6, fig. 17. Upper Cretaceous, Spain.
Verneuilina (*?*) sp. Azzaroli, **25,** pl. 6, fig. 11. Eocene, Somalia.
Virgulina sp. A Crouch, **95,** pl. 2, fig. 16. Recent, off California.
—— sp. Todd and Kniker, **378,** p. 22, pl. 4, fig. 9. Upper Eocene, Chile.
Yabeina sp. indet. Konishi, **226,** p. 162, pl. 14, fig. 1. Permian, Japan.

INDEX TO FORAMINIFERA SUPPLEMENT FOR 1948

In the Journal of Paleontology, vol. 26 (1952), p. 241, a paper was listed under Lit. No. 509 in which Tokay describes the following new forms:

Globigerina cretacea Orbigny, 1840, var. *subcarinata* Tokay, Thèse No. 1083, Univ. Genève, Fac. Sci., Inst. Géol., p. 53, pl. 1, fig. 2; pl. 3, fig. 2. Upper Cretaceous, Switzerland.
Globotruncana globulosa Tokay, Idem, p. 68, pl. 1, figs. 16–19; pl. 6, fig. 13. Upper Cretaceous, Switzerland.

Lenticulina sp. Tokay, Idem, p. 73, pl. 6, figs. 25, 26. Upper Cretaceous, Switzerland.

SUPPLEMENT FOR 1949

The following new species are listed, which appeared in a paper in Russian by D. M. Rauzer-Chernoussova, Ob ontogeneze nekotorykh paleozoiskikh foraminifer, Akad. Nauk, S.S.S.R., Trudy, Paleont. Inst., vol. 20, pp. 339–353 (No. 440 for the year 1949) not yet seen by the compiler (all from the Paleozoic of Soviet Russia):

Nodosaria postprocera Rauzer-Chernoussova, 1949.
—— *praecursor* Rauzer-Chernoussova, 1949.
—— *procera* Rauzer-Chernoussova, 1949 (preoccupied by Ehrenberg, 1854, by Wisniowski, 1890, and by Franke, 1936).
Parastaffella fraudulenta Rauzer-Chernoussova, 1949.
—— *keltmensis* Rauzer-Chernoussova, 1949.
Pseudostaffella praegorskyi Rauzer-Chernoussova, 1949.

SUPPLEMENT FOR 1950

Geinitzina sp. Glaessner, Llewellyn and Stanley, **427,** p. 24, text fig. 1. Permian, New Guinea.

SUPPLEMENT FOR 1951

In the paper by Hofker, listed under Lit. No. 155, Journal of Paleontology, vol. 26, 1952, p. 958, a new genus was erected:

ELPHIDIONONION gen. nov. Hofker, 1951, Arch. Neerland. Zool., vol. 8, no. 4, p. 356. New genus of the family Nonionidae, subfam. Nonioninae. Genotype: *Polystomella poeyana* Orbigny, 1839, Hist. Phys. Pol. Nat. Cuba, Foraminiferes, p. 55, pl. 6, figs. 25, 26. Recent.

Another new genus, proposed by Hofker in Lit. No. 153, Journal of Paleontology, vol. 26 (1952), p. 958, is as follows:

GAVELINONION gen. nov. Hofker, 1951, Naturrhist. Genootsch. Limburg, Publ., vol. 4, p. 17. New genus of the family Rotaliidae, subfam. Rotaliinae. Genotype: *Rotalia tuberculifera* Reuss, 1862, Abhandl. k. Akad. Wiss. Wien, Math.-nat. Cl., vol. 44, Abth. 1, p. 313, pl. 2, fig. 2. Upper Cretaceous.

Ruggieri, in Lit. No. **464** of the preceding Bibliography, describes the following new forms:

Sakesaria cylindrica Ruggieri, **464,** p. 5 (reprint), text figs, 1, 2, 4. Paleocene, Italian Somalia.
—— —— —— var. *costulata* Ruggieri, **464,** p. 5 (reprint), text fig. 5. Paleocene, Italian Somalia.
—— *pyrum* Ruggieri, **464,** p. 7 (reprint), text fig. 7. Paleocene, Italian Somalia.
—— *somalica* Ruggieri, **464,** p. 6 (reprint), text figs. 5, 6. Paleocene, Italian Somalia.

Nomina aperta 1951 (supplement):

Ammobaculites sp. Colom, **437,** p. 177, pl. 21. Mio-Pliocene, Spain.
Lenticulina sp. Ciry, **435,** p. 79, text fig. 1. Upper Cretaceous, Madagascar.
Reophax sp. Colom, **437,** p. 190, pl. 21, fig. 28. Pliocene, Spain.

JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, PP, 877–885, 6 TEXT FIGS., NOVEMBER 1953

PALEONTOLOGICAL NOTES

OTOLITHS OF A NEW FISH FROM THE MIOCENE OF MARYLAND

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The Miocene of Maryland has long been noted for its wealth of fossil vertebrates. These remains are mostly cetacean, but occasionally fish or reptile hard parts are found. Most of the fish material is fragmentary. Concerning these, Dr. Charles R. Eastman (1904, p. 92) in the Miocene report of the Maryland Geological Survey stated:

> The only species of bony fishes recorded from the Miocene of this state is "*Sphyraena speciosa* Leidy," represented by a single laniary tooth from Charles County. . . . This and an allied form described by Cope under the name of *Sphyraenodus silovianus* occur in the Miocene of New Jersey in company with three other Actinopterygians, as follows: *Phyllodus curvidens* Marsh, *Crommyodus irregularis* Cope, and *Phasganodus gentryi* Cope. The Eocene and Miocene of Virginia combined yield scarcely a half dozen species of bony fishes, and this group is represented with equal meagerness in North and South Carolina. In these states, however, and especially in the Eocene of Alabama and Mississippi, Teleostome otoliths occur in considerable abundance and variety; and it happens that these insignificant appearing objects are the only record that remains of a once flourishing fish fauna, which can be but inadequately reconstructed in imagination. Many of the Miocene otoliths occurring in this state are indistinguishable from those figured under a variety of titles from the Eocene of Alabama and Mississippi by Koken.

The fishes described from Maryland and Virginia Miocene beds are mostly elasmobranchs; only a few are teleosts. Hay (1928) lists the following species as being reported from the general area.

Synechodus clarki Eastman
Squatina occidentalis Eastman
Odontaspis cuspidata (Agassiz)
Odontaspis cuspidata hopei (Agassiz)
Odontaspis elegans (Agassiz)
Lamna crassidens Agassiz
Lamna obliqua (Agassiz)
Oxyrhina desorii Agassiz
Oxyrhina hastalis Agassiz
Oxyrhina minutus Agassiz
Oxyrhina sillimanii Gibbs
Corax pristodontus Agassiz
Carcharodon megalodon Agassiz
Hemipristis serra Agassiz
Galeocerdo contortus Gibbs
Galeocerdo aduncus Agassiz
Galeocerdo laevissimus Cope
Galeocerdo triqueter Eastman
Carcharinus collatus (Cope)
Carcharinus (Prionace) egertoni (Agassiz)
Carcharinus incidens Eastman
Notidanus primigenius Agassiz
Sphyrna magna Cope
Sphyrna prisca Agassiz
Raja? dux Cope
Dasyatis carolinensis Leidy
Myliobatis fragens Eastman
Myliobatis gigas Cope
Myliobatis pachyodon Cope
Myliobatis vicomacanus Cope
Aetobatis arcuatus (Agassiz)
Stroasodon profundus (Cope)
Sphyraenodus speciosus (Leidy)
Istiophorus calvertensis Berry
Acipenser ornatus Leidy
Pogonius multidentatus Cope
Protautoga conidens Leidy

The paucity of identifiable fish remains lends great importance to any object that will increase our knowledge of the fauna of Chesapeake Bay region. In many cases, the only evidence we have of the existence of certain fish families in a particular region during the Tertiary is derived from a study of otoliths. These show such a close resemblance to the otoliths of Recent fishes that it is possible to classify them according to family and often to genus. Many studies of the otoliths of fishes have been made in Europe, but little work has been done with them in this country.

The exact methods that bring about the preservation of the otolith, while the remainder of the skeleton is missing, are unknown. It may be due to decay causing the bones to separate and be lost or ground up in the surf while the more compact otolith falls to the bottom and is covered up. Or it may be due to the flesh and bones being digested in the stomachs of seals, porpoises, and other fish-eating animals while the otoliths, better able to resist the digestive juices, are discharged with the fecal matter. Sulc (1932, p. 49) in discussing the otoliths found

at Biarritz in France, stated his belief that under certain conditions, bones will be preserved in marine deposits, while under other conditions, the bones will dissolve and only the otoliths will be left. Whatever the reason, this question has not, as yet, been solved.

Eastman (1904, pl. 32, figs. 17–19), in his report on the Maryland Miocene, figured two otoliths but did not describe them. These otoliths appear to belong to a sciaenid. Since then, three more specimens have been found by Arlton Murray and Lee Kimball in the Calvert formation at Camp Canoy near Point of Rocks, Maryland. These otoliths also show the characteristics of a sciaenid and all have been assigned to that family.

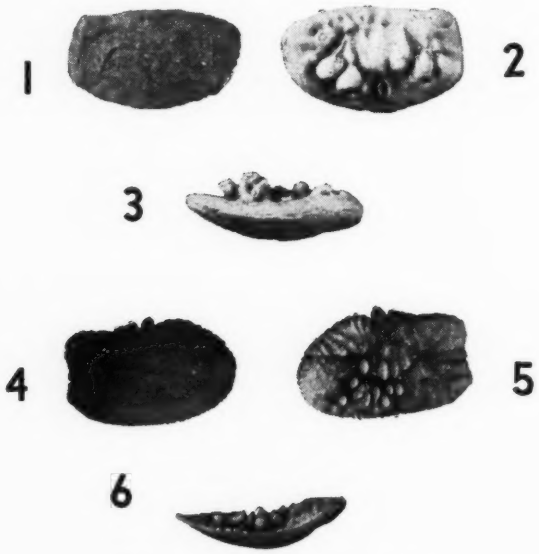
I wish to thank Drs. C. L. Gazin and D. H. Dunkle of the United States National Museum for permission to describe these specimens and for reading and criticizing this paper; also Dr. G. A. Cooper for photographing the specimens, and Dr. L. P. Schultz for the loan of the Recent otoliths for comparison.

Family SCIAENIDAE Linnaeus

SCIAENOPS EASTMANI Dante, n. sp.

Figures 1–3

Diagnosis.—Shape rectangular, outer side concave to convex, inner side convex, dorsal rim straight, low, slightly domed over junction of ostium and cauda; ventral rim rounded to straight, joining the acute anterior rim; posterior rim acute. Ostium large, longer than wide, ventral edge extending to the anterior edge; cauda long and narrow, end rounded, posterior half bent downward reaching almost to the ventral rim. Outer side high posteriorly, center depressed dorsoventrally, raised mass in center; several thick ribs in central mass extending toward and thinning out along dorsal rim, ventral rim with several high bosses. In older specimens the ribs and bosses seem to have disappeared, leaving only a trace to show where they had been. There appear to be several varieties among the specimens examined, one of which shows the cauda widening to form a flattened club-like end.



EXPLANATION OF FIGURES 1–6

FIGS. *1–3—Sciaenops eastmani* Dante, n. sp., ×2.6. Inner, outer, and side views of the holotype, USNM No. 18477. (p. 878)

FIGS. *4–6—Sciaenops ocellatus* (Linnaeus), ×1.8. Inner, outer, and side views, USNM No. 27362. (p. 879)

Comparison.—*Sciaenops eastmani* bears a slight resemblance to *Otolithus* (*Sciaenidarum*) *irregularis* Koken[1] (1884) from the upper Oligocene and Miocene of Germany, but differs from it in having a mass in the center of the outer side rather than one at either end, and in the shape and curve of the cauda. The nearest living relative from Chesapeake Bay appears to be *Sciaenops ocellatus* (Linnaeus) (figures 4–6), to which *S. eastmani* bears a close relationship. The fossil, however, lacks serrations around the rim, and differs also in the shape of the ostium and cauda and in the curvature of the cauda.

This species is named in honor of Dr. Charles R. Eastman by whom it was first figured.

Type.—USNM No. 18477.

Hypodigm.—USNM Nos. 9401, 18478.

Distribution.—Calvert and St. Mary's formations, Maryland.

Measurements:

Length	Width	Thickness
8.9 mm.	5.7 mm.	3.3 mm.
8.6 mm.	5.7 mm.	2.4 mm.

[1] Koken in his studies on otoliths was forced to create his own system of nomenclature. He assigned all specimens to the genus *Otolithus*, then in parenthesis, added the name of the genus or of the family in the genitive plural, and followed this by the species name. This system is followed only in cases where it is impossible to assign the otolith to a definite genus.

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NOTES ON THE LOWER CRETACEOUS AMMONITE *COLOBOCERAS*[1]

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The continued ascribing of certain late Lower Cretaceous ammonites to a genus "*Lemuroceras*" (McLearn and Kindle, 1950; McLearn, 1945) makes it desirable to point out that that name is antedated by *Coloboceras* (Crickmay, 1927). The former name was instituted for the group of *L. aburense* (Spath, 1942) which is, however, essentially congeneric with the type of the prior genus *Coloboceras*, namely, "*Sonneratia*" *stantoni* Anderson, 1902.

The failure of paleontologists dealing with these forms to recognize *Coloboceras* may be due in part to the fact that the genus was named without accompanying illustrations, and in part to the facts that Anderson had described his species very imperfectly, and repeatedly confused their relationships. Anderson, as late as 1938 (Anderson, 1938), was unaware of the existence of the important group of ammonites for which Spath later proposed the name *Lemuroceras*, and was so intent upon the purpose of suppressing *Coloboceras* as a name for the group typified by his species "*Sonneratia*" *stantoni* that he failed completely to realize that he was dealing with one of the most important of late Lower Cretaceous fossil genera.

Coloboceras is known from Madagascar where it occurs with ammonites of the European *mammillatum* (*Douvilleiceras mammillatum*) zone, from India, California, British Columbia, Alberta, and the Northwest Territory of Canada. As far as is known, it is confined to deposits of early middle Albian age.

California species include:

C. stantoni Anderson
C. mulleri Anderson
C. crossi Anderson.

[1] Published by permission of Imperial Oil Limited, Toronto, Canada.

Alberta species include:

C. mcconnelli Whiteaves
C. belli McLearn
C. irenense McLearn.

Coloboceras is a dwarf ammonite, a phaulomorph, to be exact in terminology, of the family Hoplitidae. Anderson's supposition of the connection of the California species to *Sonneratia* is mere conjecture; the pertinent evidence is all contrary to such a supposition. *Coloboceras* species are all small platycone shells, with convergent flanks and slightly flattened venter. The ribbing is low, obtuse, slightly flexuous, dividing inconspicuously into approximately twice as many secondaries as primaries, commonly weakened slightly both on flank and on venter. The septal line, though essentially hoplitid, is very simple in plan and without any elaboration of detail.

Lemuroceras Spath includes exactly the same group of forms, hence is a synonym, and therefore unavailable as a name.

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HEAVY LIQUID CONCENTRATION OF FORAMINIFERA

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In the Journal of Paleontology for December, 1933, vol. 7, p. 439, the author described a method of separating washed samples to concentrate the Foraminifera by using bromoform and diluting it in the separation funnel with methanol. The method here described is believed to be an improvement and involves the use of tetrabromethane or acetylenetetrabromide and acetone and preparation of the dilute solution before using.

The various steps in the process are as follows:

1. Procure separatory funnel, stand, flasks, funnels, fast filter papers, tetrabromethane and acetone.

2. Wash the sample in the usual way and remove all soluble hydrocarbons with a suitable solvent such as carbon tetrachloride.

3. Prepare one bottle of tetrabromethane by diluting with acetone until a piece of feldspar slowly sinks. Keep one bottle of tetrabromethane of full gravity.

4. Into separatory funnel pour ten to twenty mls. of full gravity tetrabromethane. Then, not before, pour in fine, dry, washed sample and if necessary add enough heavy tetrabromethane to float the whole sample. Stir if necessary and allow to separate.

5. Onto filter paper draw off sunken portion of sample and all possible heavy tetrabromethane. Allow liquid to filter back into stock bottle of heavy tetrabromethane for reuse. Transfer funnel and filter paper with heavy portion of sample to an empty flask, wash about three times with acetone and and dry. This is the heavy concentration with pyritized Foraminifera and heavy minerals.

6. Pour into same separatory funnel the light, diluted tetrabromethane in such a way as to thoroughly mix all of the remainder of the sample. Allow to separate. Onto filter paper draw off sunken portion of sample and all remaining liquid leaving light portion of sample in funnel. Allow liquid to filter back into stock bottle of light tetrabromethane for reuse. Transfer funnel and filter paper with middle portion of sample to an empty flask, wash about three times with acetone and dry. This is the sandy

portion of the sample and usually contains some broken and arenaceous Foraminifera but after examination can often be discarded.

7. Onto filter paper, with acetone, wash the portion of the sample remaining in the separatory funnel. Dry. This is the light portion of the sample and if the separation has been properly carried out contains the highest concentration of Foraminifera and any undisintegrated shale. Rewashing on a fine sieve may occasionally be desirable.

When the Foraminifera are calcite filled, as is often the case in the Miocene of California, the process may be varied by using a somewhat heavier light tetrabromethane, that is, adjusted so that a piece of calcite will slowly sink. This will drop the calcite-filled Foraminifera and float any sand and shale. (By the use of tetrabromethane of different dilutions and hence different gravities the original sample may be divided into any desired number of fractions.)

Save the acetone washings. They may be reused for the first washing of the samples. To recover the tetrabromethane, add the washings to an excess of water, shake in a bottle and let stand. The tetrabromethane will settle and the water-acetone mixture may be decanted or they can be separated in the separation funnel. This process should be repeated if the tetrabromethane still has a strong acetone odor. Allow this tetrabromethane to stand in an open dish for two or three days for evaporation of any remaining acetone and water. It will then be restored to full gravity. The gravity may easily be tested with various minerals of known specific gravity.

When the light stock of tetrabromethane becomes too heavy, due to mixture with heavy tetrabromethane and to evaporation of acetone, and starts to float the sand, again add acetone until feldspar slowly sinks.

Discolored tetrabromethane may be clarified by stirring in fuller's earth and then filtering it through fuller's earth. The acetone-water mixture may be fractionally distilled for recovery of acetone but is usually not worth the time, effort and fire hazard involved.

Tetrabromethane is stated to be less toxic than other heavy liquids commonly used. However, good ventilation is essential.

This process will be found to be easily varied, very flexible and can be adjusted to suit most kinds of samples. Overstandardization of the process will sacrifice flexibility and result in inferior concentrates.

SEPARATION OF SPORES AND POLLEN FROM SILICEOUS ROCKS

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Fossil spores and pollen grains are found in many sedimentary rocks that lack other fossils for stratigraphic correlation. These organic microfossils originate on land and, in the main, are airborne to the place of deposition. They are not limited, therefore, to any one type of aqueous environment but are deposited in marine, brackish and non-marine basins. Such a distribution suggests that fossil spores and pollen would be useful for correlation across environmental facies as well as from basin to basin.

The separation of spores and pollen from the rock is a critical step in the study of these fossils because they are very small and because their aggregate volume is small compared to the total volume of the rock matrix. They are separated from coal by maceration with Schulze's solution and from carbonates with hot hydrochloric acid. Hydrofluoric acid is used to break down siliceous rocks.

The separation of organic microfossils from sandstones seldom presents any difficulties. The end products of the reaction with hydrofluoric acid are gaseous silicon fluoride and water. Insoluble materials are usually present in small quantities and do not interfere with microscopic examination.

On the other hand, when rocks containing clays are treated with hydrofluoric acid, minerals and organic materials that are in-

soluble in the acid, as well as reaction products that are difficult to dissolve, form a bulk of residual material that often hides the microfossils. Reissinger (1939, p. 3) identified the insoluble reaction products as brown flakes of aluminum fluosilicates. However, optical and x-ray properties indicate that these materials are mixtures of double fluorides of calcium, magnesium, sodium, and potassium. The brown coloration is caused by organic impurities.

The separation of the organic microfossils from the residual materials after treatment with hydrofluoric acid is accomplished by more or less elaborate procedures. Assarsson and Granlund (1924) (English summary in Erdtman, 1943, pp. 36–37) wash the residues with hydrochloric acid, water and finally with glacial acetic acid.

Reissinger (1939, pp. 2–13, and 1950, pp. 100–101) treats the residues with hot dilute hydrochloric acid. The solution is allowed to settle for a long period until it becomes clear. The supernatant liquid is then drawn off with a suction tube and the residue transferred to a very large, wide-mouthed, stoppered, glass container. Filtered water is added to a depth of ten centimeters and the container closed and shaken vigorously. After settling for twelve hours, the water is slowly drawn down to a depth of two centimeters. This process is repeated until the solution is clear.

The method used by Wilson and Hoffmeister (1952, p. 28) for the separation of small Foraminifera is a modification of Reissinger's procedure for pollen separations. The last washing steps are speeded up by the use of a centrifuge.

For ease in study, pollen and spore preparations must be relatively free from materials that interfere with microscopic examination and the separation procedure must be adaptable to the preparation of large numbers of samples in a routine manner. None of the preceding methods fulfills both requirements. The following procedure, developed in this laboratory for siliceous samples, reduces the time and space requirements in sample preparation by eliminating long settling periods of large volumes of liquid. It also speeds up and increases the accuracy of the microscopic examination by eliminating interfering materials.

PROCEDURE

Thoroughly wash the sample with distilled water to remove surface contamination and dry. Crush to an eight or ten mesh fineness and cover with hydrofluoric acid in a polyethylene, polystyrene, hard rubber, copper, lead or monel metal beaker. Acid should be added very slowly to avoid spattering and boiling over, particularly with samples containing carbonates. Acid treatment should be carried out with extreme care in a fume hood. Hydrofluoric acid burns are painful and difficult to heal. The acid fumes are also destructive to glass.

Digest the sample in acid with occasional stirring for 24 hours. If the sample has not broken down completely in that time, pour off the supernatant liquid after residue has settled and add fresh acid. Continue digestion until disintegration is complete.

Allow the residue to settle, decant supernatant liquid, and fill beaker with distilled water. Stir, settle and decant. This initial dilution in the original vessel eliminates the necessity of handling concentrated acid in the next step. The residue is then transferred to a lusteroid centrifuge tube for washing and centrifuging. Washing and centrifuging is repeated until water shows slight acid or neutral reaction.

Transfer residue to a glass centrifuge tube and wash three times with 95 per cent alcohol to remove the water. Fill tube about three-fourths full with bromoform-alcohol mixture having a specific gravity of 2.0. Stir the mixture vigorously so that the slurry is thin and well mixed. The organic particles, including the microfossils, can then rise easily to the top. Settle the heavy solids by centrifuging. Transfer the heavy liquid with the floating organic materials to a small separatory funnel. Wash any organic material clinging to the sides of the tube into the funnel with a fine stream of heavy liquid from a wash bottle. Let the mixture stand in the separatory funnel for several minutes to permit the organic particles to rise to the top again, and then draw off most of the heavy liquid.

The heavy liquid can be used again after filtering and adjusting the specific gravity by adding bromoform or alcohol as needed. Organic solvents other than alcohol may be used to lower the specific gravity of bromo-

form to 2.0, but non-polar materials such as carbon tetrachloride cause the residues to become sticky and hinder the separation of the organic particles. Acetone evaporates quickly, changing the specific gravity of the heavy liquid. When the bromoform becomes too discolored for further use, it may be distilled under reduced pressure.

Flush the organic residue and remaining heavy liquid into a glass centrifuge tube with 95 per cent alcohol and remove the bromoform by washing twice with alcohol.

Add 10 per cent sodium hydroxide solution and digest over night to dissolve alkali-soluble humic acid derivatives.

Wash twice with distilled water and add concentrated nitric acid as a clearing agent. Let stand one-half hour. Wash and centrifuge with distilled water until wash water is neutral. Wash three times with 95 per cent alcohol.

Transfer the residue to a small vial with a small amount of 95 per cent alcohol. Add a drop of a dye such as basic fuchsin or safranin 0 (0.1 per cent in alcohol).

The organic microfossils may be examined in water mounts or on permanent slides made with gelatin jelly or diaphane. Good slides can be prepared by transferring with a medicine dropper a drop or two of the alcohol containing a suspension of the organic particles to a clean microscope slide. The alcohol suspension is spread over the slide to about the size and shape of the cover slip with the tip of the dropper or with a needle. The alcohol is then allowed to evaporate and a drop of diaphane is placed in the center of the area. The material on the slide must be completely dry or the diaphane will become cloudy. Warming slide will speed up evaporation. The cover glass is lowered onto the diaphane. The spores and pollen grains remain in a single plane on the slide.

The mounts may be made thin by applying a slight pressure on the cover glass. For this purpose, a metal plate on which are mounted several spring clips of the type used on microscope stages is useful. The slide is placed on the plate with the clip resting on the cover glass until the diaphane has set around the edges. Setting of the diaphane may be speeded up by warming the slide for several hours at about 45°C. on a warming table or in a drying oven.

This procedure should be carried out with the same care as a quantitative chemical analysis. The amount of spores, pollen grains and other insoluble organic materials found in many sedimentary rocks is so small that it may be lost in transferring from one container to another or in decanting wash liquids. The end product contains spores and pollen grains mixed with fragments of plant and animal tissues and other unidentifiable amorphous bits of organic matter. These extraneous materials like the spores and pollen, are resistant to the chemical reactions of the procedure. They are usually not present in sufficient quantity to be a serious detriment in the microscopic examination and they frequently contain organic microfossils of other types which are interesting and useful.

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THE STROMATOPOROID GENUS *MILLESTROMA* GREGORY

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In 1898 J. W. Gregory described and figured, as a new genus and species, a stromatoporoid from the Turonian of Abu Roasch, near Gizeh, Egypt, giving it the name *Millestroma nicholsoni*. The description and figures were of one specimen, which is thus the holotype;[1] the species is, by monotypy, the genotype.

Though Gregory recognized the affinity of his new genus to Nicholson's milleporoid group of the Stromatoporoidea, his statement of the presence, in the coenosteum, of "cyclo-systems" (a macropore [gastropore] surrounded by six or seven micropores [dactylopores]), and the implied absence of astrorhizae, make it difficult to allocate his genus to any of the known families, or relate it to the known genera.

In 1927 Kühn, in his classification of the Stromatoporoidea and allocation of the various genera, ignored Gregory's genus. Later, Steiner (1932) and Yabe and Sugiyama (1935) recognized its likeness to the members of the Milleporididae, the former likening it to *Milleporidium* and the latter to *Milleporella*.

Examination of the holotype led the writer to the conclusion that Gregory had misinterpreted the structure of his new form. The reticulum is not dimorphic: there are coenosteal tubules of all diameters up to 0.40 mm., though they are generally about 0.20–0.30 mm., and the occurrence of large ones surrounded by smaller ones, if such a pattern does exist, is fortuitous.

Though Gregory did not specifically mention astrorhizae, they are implied by his description and figures since he states: "The surface is also marked by irregular, sinuous, radial valleys; on the ridges between them the pores are often linear in arrangement." Such valleys are shown in Gregory's figures (1898, p. 13) at b, figure 1a and at b, figure 1c. These valleys are the expression on the surface of the radiating, horizontal, astrorhizal canals occurring within the coenosteum (see c, fig. 1d); they are sparsely and irregularly distributed and are not superposed. The skeletal microstructure shown by the thin sections of the type specimen is not clear. It is apparently of the trabecular type known as "jet d'eau."

The emended description of *Millestroma nicholsoni* Gregory is as follows:

Coenosteum encrusting [type specimen; ovoid cylindrical, 83 mm. by 40 mm., coenosteum about 20 mm. thick, encrusting a gastropod (*?Nerinaea*)]. Surface undulating and slightly nodular, covered with pores with no definite arrangement, each about 0.2 mm. in diameter. Occasional astrorhizal canals (shallow, sinuous, and radiating grooves on surface, each about 0.20 mm. across). Mamelons absent.

Coenosteum composed of reticulum in which the vertical elements are dominant and form coenosteal tubules, approximately cylindrical and parallel, normal to the surface and of considerable extent. Tubules up to 0.40 mm. in diameter, generally from 0.20 to 0.30 mm., walls about 0.12 to 0.20 mm. thick. Indefinite horizontal (concentric) lamellae occur sparsely, crossing several tubules. There is no zoning of the reticulum and no latilamellae. Tubules are tabulate, the tabulae, approximately flat and horizontal, generally being about 0.70–0.80 mm. apart. The astrorhizae are not superposed.

The walls of tubules are formed of vertical pillars with joining lamellar extensions. Their structure is of the "jet d'eau" type, formed of a vertical series of sclerodermites, centers of calcification (dark spots in thin section) from each of which radiate upwards fascicles of fibrous crystals.

Millestroma nicholsoni is thus closely similar to the various genera of the Milleporoidea and is apparently congeneric with

[1] The holotype and the sections made from it are now in the collections of the Geological Survey and Museum of Egypt, where in 1950 the writer, by the kind permission of the Director, M. I. Attia, was able to examine them. His visit to Cairo was made possible by the directors of the Iraq Petroleum Company, Limited, to whom he is duly grateful.

such species as *Milleporella sardoa* Deninger 1906, *M. marticensis* Dehorne 1920, *M. fasciulata* Yabe and Sugiyama 1935, and *Istriactis*[2] *adriaticus* Munier-Chalmas 1883, all species belonging to the genus *Milleporella*, characterized by monomorphic coenosteal tubules. The genus *Milleporella* (genotype: *M. sardoa*) was founded by Deninger in 1906, and is thus a junior synonym of *Millestroma* Gregory 1898, which thus replaces it both as the appropriate genus for the above species and as the root of the family name, which becomes Millestromidae.

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[2] *Istriactis* Munier-Chalmas 1883 is a nomen nudum; *Istriactis* Dehorne 1920 is a junior synonym of *Millestroma*.

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NOMENCLATURAL NOTES

NOTES ON CAMBRIAN TRILOBITES—HOMONYMS AND SYNONYMS

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In the course of investigating a number of trilobite families for the Treatise of Invertebrate Paleontology, I have found it necessary to propose several new names for homonyms, to indicate a number of generic synonyms and to make certain corrections to published generic ranges.

Rasettia is proposed to replace *Platycolpus* Raymond, 1913, Victoria Mem. Mus., Bull. vol. 1, p. 63, homonym of *Platycolpus* Donald, 1900. It is named for Dr. Franco Rasetti.

Princetonella is proposed to replace *Calyptomma* Resser, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 37, homonym of *Calyptomma* Tattersall, 1909. It is named from Princeton, Montana.

Dictyella Kobayashi, 1933, Japanese Jour. Geology and Geography, vol. 11, nos. 1–2, p. 140, is a subjective junior synonym of *Xenostegium* Walcott, 1925. Kobayashi states that the distinction between the two genera is that in *Dictyella* the spine on the pygidium is a median border spine whereas in *Xenostegium* it is a terminal axial spine. However, only the single holotype pygidium of the type species appears to show such a feature, and this specimen is obviously flattened. All other pygidia which Kobayashi has subsequently assigned to *Dictyella* clearly have a terminal axial spine like that of *Xenostegium* and it seems reasonable to assume that the appearance of a median border spine in the flattened pygidium which Kobayashi selected as the type is due to the very poor preservation, especially since a similar effect can be seen on poorly preserved pygidia of accepted *Xenostegium* species.

Protillaenus Raymond, 1937, Geol. Soc. America, Bull., vol. 48, p. 1118, is a subjective junior synonym of *Blountia* (*Homodictya*) Raymond, 1937, of the same fauna, whereas *Blountina* Lochman, 1944, is not a subjective junior synonym of *Protillaenus* as recently suggested by Shaw (1952, p. 474). Cranidia and pygidia of *B.* (*Homodictya*) were first adequately figured by Rasetti (1946) and there can be little doubt that the pygidia are correctly associated. The holotype and two paratypes of *Protillaenus* are distorted and very poorly preserved internal molds, from which only a few features can be made out with any certainty: (1) the shape of the glabella is subovate, i.e., conical with narrowly rounded front; (2) the anterior border furrow is obsolete. Both features are also characteristic of the cranidium of *B.* (*Homodictya*) but in the cranidium of *Blountina* the shape of the glabella is broadly conical with the sides nearly parallel to the broadly rounded front. I have accepted Shaw's assignment of *Homodictya* as a subgenus of *Blountia* since among the numerous species of *Blountia* now known a more or less continuous series exists from *B.* (*Blountia*) *mimula* to *B.* (*Homodictya*).

Ithycephalus Resser, 1938, Geol. Soc. America Sp. Paper 15, p. 82, is not a subjective junior synonym of *Kingstonia* Walcott, 1925, as recently suggested by Shaw (1952, p. 471). The type cranidia and recently acquired topotype material of *Ithycephalus typicalis* Resser show that the glabella is narrow elongate rectangular with rounded corners, there is no pre-glabellar area, the anterior border furrow runs into the preglabellar furrow and the anterior border is slightly convex and downsloping. In these features the cranidia of *Ithycephalus* are morphologically most similar to those found among the Pagodidae, as *Bienella* Lochman, 1944.

Ucebia Walcott, 1925, Smithsonian Misc. Coll., vol. 75, no. 3, p. 118, is a direct subjective junior synonym of *Kingstonia* Walcott, 1925, as indicated by Resser (1936). Tasch (1952) has already correctly pointed out that variation in length and convexity of the posterior limb is definitely a specific rather than a subgeneric character. This

feature can be readily ascertained in any large suite of kingstonid cranidia, such as I have obtained both from Missouri and Montana, and as Tasch reports from Pennsylvania.

Tatonaspis Kobayashi, 1935, Japanese Jour. Geology and Geography, vol. 12, p. 48, and *Yukonaspis* Kobayashi, 1936, Jour. Paleontology, vol. 10, p. 164, are both subjective junior synonyms of *Macelloura* Resser, 1935. The holotypes of *Macelloura dia* (Walcott) and *Yukonaspis kindlei* Kobayashi are peeled cranidia (internal molds) whereas that of *Tatonaspis alaskensis* Kobayashi is an unpeeled cranidium. Rasetti (1945) subsequently demonstrated the identity of the peeled and unpeeled cranidia.

In 1942 (b) Resser described a pygidium as *Macelloura transversa*. This pygidium is structurally the type characteristic of genera such as *Lecanopyge* and *Platydiamesus*, and I cannot accept it as correctly associated with the cranidium of *Macelloura*. I would expect the pygidium of *Macelloura* to be narrowly transverse as in *Illaenurus* and to date no such pygidium has been obtained.

Piedmontia Resser, 1938, Geol. Soc. America Sp. Paper 15, p. 94, and probably *Holstonia* Resser, 1938, Geol. Soc. America Sp. Paper 15, p. 81, are subjective junior synonyms of *Bonneterrina* Lochman, 1936. The type cranidium of *Holstonia* is a cranidium in the metaspid stage and it may never be possible to demonstrate positively the adult relations of the form.

Sneedvillia Resser, 1938, Geol. Soc. America Sp. Paper 15, p. 98, is a subjective junior synonym of *Crepicephalus* Owen, 1852. The type is a badly crushed cranidium.

Mesocrepicephalus Kobayashi, 1935, Jour. Fac. Sci., Imp. Univ. Tokyo, sec. 2, vol. 4, pt. 2, p. 277, is a subjective junior synonym of *Crepicephalina* Resser and Endo, 1935.

Pseudolisania Kobayashi, 1935, Jour. Fac. Sci., Imp. Univ. Tokyo, sec. 2, vol. 4, pt. 2, p. 162, and *Bernicella* Frederickson, 1949, Jour. Paleontology, vol. 23, p. 347, are subjective junior synonymns of *Cheilocephalus* Berkey, 1898.

Irvingellina Kobayashi, 1936, Japanese Jour. Geology and Geography, vol. 15, nos. 3–4, p. 175, and *Parairvingella* Kobayashi, 1938, Japanese Jour. Geology and Geography, vol. 15, nos. 3–4, p. 175, are subjective junior synonyms of *Irvingella* Ulrich and Resser, 1925. I agree with Westergård (1947) that among known species of *Irvingella* there is continuous gradation in the width of the pre-glabellar area and the degree of obsolescence of the anterior border furrow, and that consequently these features are not of generic value.

Schmidtaspis Kobayashi, 1944, Jour. Fac. Sci., Imp. Univ. Tokyo, sec. 2, vol. 6, pts. 11–12, p. 310, is a subjective junior synonym of *Dartonaspis* B. M. Miller, 1936. The latter genus is not a synonym of *Chariocephalus* Hall, 1863. The characters of the genus *Chariocephalus* must be based upon the type species, *C. whitfieldi* Hall, 1863, and cannot be redefined or emended upon the characters of *Dartonaspis* as Resser did in 1942(b) when he described a number of species of *Dartonaspis* as *Chariocephalus*. In *Chariocephalus* the glabella is quadrate but the anterior lobe is never enlarged, the palpebral lobes are over medium size, centered on the anterior third of the glabella with the front end even with the front of the glabella, the posterior branch of the facial suture is of medium length and the free cheek has a long lateral genal spine. In *Dartonaspis* the glabella is quadrate but the sides commonly diverge anteriorly and the anterior lobe is usually slightly swollen, the glabellar furrows are commonly strong, the palpebral lobes are the entire length of the glabella, consequently the posterior branch of the facial suture is very short, and the free cheek has a short lateral genal spine. Except for *C. whitfieldi*, all described species assigned to *Chariocephalus* show the characters of *Dartonaspis* and there are no known species showing any gradation between the two genera. In fact *Chariocephalus* appears to be most closely related to *Drumaspis* and *Elvinia* whereas *Dartonaspis* is clearly one of the Komaspidae. ■

Mêtisia Resser, 1937, Smithsonian Misc. Coll., vol. 95, no. 22, p. 19, is a subjective junior synonym of *Armonia* Walcott, 1925. Rasetti (1948) demonstrated that the age of *Mêtisia mêtisensis* (Walcott) is late Middle Cambrian, not Lower Cambrian as Walcott originally supposed.

Punctularia Raymond, 1937, Geol. Soc. America Bull., vol. 48, p. 1123, is a subjective junior synonym of *Aposolenopleura*

Raymond, 1937. The trivial name of *Punctularia brevifrons* Rasetti, 1945, Jour. Paleontology, vol. 19, p. 472, as a result must yield priority to *Aposolenopleura? brevifrons* Rasetti, 1944, and a new trivial name, *Punctularia quebecensis*, is here proposed for the former.

Stenelymus Raymond, 1937, Geol. Soc. America Bull., vol. 48, p. 1100, is a subjective junior synonym of *Genevievella* Lochman, 1936. The holotype of *Stenelymus kobayashi* Raymond agrees in every detail with *Genevievella* except that the fixed cheeks appear to slope down, a feature attributed to the crushed and distorted condition of the specimen.

Sulcocephalus Wilson, 1948, Jour. Paleontology, vol. 22, p. 30, is a subjective junior synonym of *Berkeia* Resser, 1937. Wilson and Frederickson (1950) listed only two distinctions between the genera: (1) *Sulcocephalus* has narrower fixed cheeks than *Berkeia;* and (2) *Sulcocephalus* has a central posterior extension of the border. In 1951 Wilson gave a generic diagnosis of *Berkeia*, pp. 623-624, in which he states, "Width of fixed cheek ratio from slightly more to slightly less than 2." This statement clearly encompasses the fixed cheek ratio of the known species of *Sulcocephalus* and leaves only feature 2 as a distinction between the genera. Feature 2 has never been considered of more than specific importance in other genera of trilobites, and I do not believe it should have generic significance in this case.

I concur with Bell, Feniak and Kurtz (1952) in placing *Plataspella* Wilson, 1949, as a synonym of *Iddingsia* Walcott, 1925. Wilson (1951, p. 646) suggests that the two genera are the end members of an intergrading series of species. If such a situation could be demonstrated, it would be most suitable to recognize *Plataspella* as a subgenus characterizing one end of the series, and *Iddingsia* as the other end. However, the known species indicate that the characteristics of the supposed two groups occur mixed together at random and do not form a continuous series changing from one group to the other. Thus it must be recognized that *Iddingsia* is a plastic genus in which in the cranidium the strength of the anterior border furrow and the glabellar furrows may vary from weak to strong, the width of the anterior border and pre-glabellar area may vary, and an occipital spine or node may be present. *Iddingsia* is not unusual in these features, for many other accepted Upper Cambrian trilobite genera show as much specific variation.

Enontioura Resser, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 43, is a subjective junior synonym of *Plethometopus* Ulrich, 1931. Undescribed exoskeletons obtained by Rasetti from boulders of Lévis conglomerate show that the type of pygidium on which *Enontioura* was based is associated with the cranidia of *Plethometopus.*

Stenocombus Raymond, 1937, Bull., Geol. Soc. America, vol. 48, p. 1106, is a subjective junior synonym of *Blountia* Walcott, 1916.

Howellaspis Lochman and Denson, 1944, Geol. Soc. America Sp. Paper 54, p. 125, is a subjective junior synonym of *Bolaspidella* Resser, 1937.

Asioptychaspis Kobayashi, 1933, Japanese Jour. Geology and Geography, vol. 11, nos. 1–2, p. 116, and *Fengshania* Sun, 1935, Paleontologia Sinica, ser. B. vol. 7, fasc. 2, p. 28, are subjective junior synonyms of *Ptychaspis* Hall, 1863. The genotypes of neither Asiatic genus differ in any significant generic character from the genotype and other accepted species of *Ptychaspis*, and I do not believe the fact of occurrence in northeastern Asia alone is sufficient reason for separating these species from the North American species. Resser (1942a) placed the genotype of *Fengshania* in *Quadraticephalus*, but in 1935 Sun had already pointed out several features of the cranidium which precluded placing it in *Quadraticephalus*. Until the species can be restudied with more and better material, I am following the diagnosis of Sun.

In 1942(a) Resser placed *Changia* Sun, 1924, in synonymy with *Quadraticephalus* Sun, 1924. World conditions have made it impossible to either examine the types or obtain casts of them, so that Sun's original publication remains the only reference source. Examination of Sun's figures has led me to doubt the validity of Resser's action, and I believe the genera should be kept distinct for the present. *Quadraticephalus*, genotype *Q. walcotti* Sun, is a well-defined and fairly widespread genus of the

late Upper Cambrian of northeastern Asia and a number of valid species belong to it. The cranidium is characterized by an essentially rectangular, elongate glabella with three pairs of faint glabellar furrows, posterior pair may be complete; eye lobes under medium size and opposite anterior third of glabella; posterior limb a broad, long (tr.) triangle. The pygidium is transverse with a medium border. *Quadraticephalus* is definitely a member of the Ptychaspidae. To date the generic characters of *Changia chinensis* Sun, the genotype, have been noted in no other species. The genotype is known from three syntype cranidia, some doubtfully associated free cheeks and one pygidium. The cranidia show a cylindrical glabella with the anterior lobe rounded and somewhat expanded, three pairs of strong glabellar furrows, the posterior pair complete and the second pair frequently complete; the eye lobes over medium size and opposite the anterior glabellar furrows; posterior limbs narrow (sag.) and strap-like. The single pygidium is subcircular in shape with a long tapered axis showing at least nine axial rings; apparently no border furrow, the pleural platforms merging into the border. Sun says the interpleural grooves extend onto the border, but the surface of the figured specimen is too poor to show this feature. The characters of the cranidium suggest that the affinities of *Changia* are with the Dikelocephalidae.

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ANALYSIS AND DISCUSSION OF NINE CAMBRIAN TRILOBITE FAMILIES

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While investigating a number of trilobite families for the Treatise of Invertebrate Paleontology, I have found it necessary to describe several new families and subfamilies, and for several old families I have been able to demonstrate more concisely their probable phylogeny.

Three new families are proposed: the Lecanopygidae for the reception of *Lecanopyge* Raymond, 1937, *Platydiamesus* Raymond, 1937, *Rasettia* Lochman, 1953, *Resseraspis* Rasetti, 1945, and *Strigigenalis* Whittington and Ross, 1953; the Camaraspidae for *Camaraspis* Ulrich and Resser, 1925, *Camaraspoides* Frederickson, 1949, *Kazelia* Walcott and Resser, 1924, and *Koldinia* Walcott and Resser, 1924; and the Bathynotidae for *Bathynotus* Hall, 1860, and *Bathynotellus* Lermontova, 1940.

The Lecanopygidae are defined as: Trilobites with opisthoparian subisopygous exoskeleton; glabella broadly conical to sub-

quadrate, pre-glabellar area present or absent, all furrows narrow and shallow, eyes about medium size, usually opposite center of glabella, fixed cheek-palpebral area very narrow, posterior area strap-like in shape; free cheek with short slender genal spine. Thorax unknown. Pygidium semicircular, axis wider or narrower than pleural regions, length variable, often with low post-axial ridge, usually 3 axial rings, no border furrow, medium-width border. Outer surface smooth. Derivation: Asaphiscidae.

The Camaraspidae are defined as: Trilobites with opisthoparian subisopygous exoskeleton; glabella broadly conical, front rounded, two pairs glabellar furrows faint or absent, anterior border furrow faint or absent, frontal area common, axial furrow shallow, occipital furrow most persistent, eyes about medium size, posterior to center of glabella, fixed cheeks downsloping, width variable; free cheek with genal spine or rounded genal angle. Thorax unknown. Pygidium transverse, axis wider than pleural regions, tapered three-fourth or nearly full length, 3–5 axial rings, all furrows faint or obsolete. Outer surface smooth. Polyphyletic derivation.

Bynumiella? oklahomensis Resser, Smithsonian Misc. Coll., vol. 103, no. 5, p. 58, 1942, appears to be congeneric with *Kazelia*, Walcott and Resser, 1924.

Camaraspis guillermoi Richter and Richter, 1940, and *Camaraspis onyx* Richter and Richter, 1940, are not congeneric with *Camaraspis* Ulrich and Resser, 1924. Thus the Camaraspidae as now constituted are an Upper Cambrian family of North American and Arctic Eurasian distribution.

The Bathynotidae are defined as: Trilobites with opisthoparian elliptical exoskeleton, micropygous; large cylindrical glabella, tapered to rounded front, 2–3 pairs glabellar furrows, posterior pair complete, doublures of free cheeks joined to hypostome through a pair of oblique sutures, no rostrum, preglabellar area very short (sag.) or absent, eyes three-fourth length of glabella, wide eye ridges, occipital spine or node present, fixed cheeks downsloping, palpebral area slightly less than glabellar width, posterior area slightly wider; free cheek with very narrow eye platform and long stout recurved genal spine. Thorax of 13 segments, axis wide, convex, may have axial spine or node, pleurae narrow, furrowed, ending in rigid spines, eleventh segment macropleural, twelfth and thirteenth reduced. Pygidium semicircular to subtriangular, axis wide, nearly full length, up to four faint axial rings, pleural regions very narrow, up to three faint pleurae. Outer surface granular.

The absence of a rostrum and the unique position of the hypostome on the ventral surface indicate that there is no relationship between the two late Lower Cambrian-early Middle Cambrian genera, *Bathynotus* and *Bathynotellus*, and the much later genera of the Komaspidae, which very clearly were derived from Middle Cambrian ptychoparids. This unique condition also strongly suggests that the Bathynotidae may well have developed independently from the other primitive trilobite stocks, and are not related to the other Lower Cambrian trilobite families (Rasetti, 1952).

The Plethopeltidae Raymond, 1925, are recognized as a separate family as was recently suggested by Shaw (1952). The following genera are now placed in this family: *Plethopeltis* Raymond, 1915, *Arapahoia* Miller, 1936 (syn.: *Hesperaspis* Stoyanow, 1936), *Leiocoryphe* Clark, 1924, *Paraplethopeltis* Bridge and Cloud, 1947, *Plethometopus* Ulrich, 1931 (syn.: *Enontioura* Resser, 1942), *Stenopilus* Raymond, 1924, *Strotocephala* Raymond, 1937.

The Kingstoniidae Kobayashi, 1933, are recognized as a separate family. I cannot agree with Shaw (1952) that this group of genera should be considered a subfamily of the Asaphiscidae. Neither *Kingstonia* nor any of the other genera referred here by myself and Shaw show any significant features of cranidium or pygidium which would link them closely to any member of the Asaphiscidae, and the small, transverse, narrow-bordered pygidium suggests derivation rather from Middle Cambrian ptychoparids. I believe that most if not all of these genera developed independently from ptychoparids, and are now grouped together because they resemble each other in the general tendency to a convex cephalon and obsolescence of furrows. I place in the family: *Kingstonia* Walcott, 1925 (syn.: *Ucebia* Walcott, 1925), *Ankoura* Resser, 1938, *Brachyaspidion* Miller, 1936, *Bynumia*

Walcott, 1925, *Bynumiella* Resser, 1942, *Bynumina* Resser, 1942. The genus *Kingstonia* is limited to the Dresbachian of North America; the report by Walcott (1925, p. 103) of its occurrence in the late Upper Cambrian (Ozarkian) of northern Vermont is unverified by specimens (personal communication, A. R. Palmer, 1952); and the species assigned to this genus by Kobayashi from the late Upper Cambrian of Asia actually belong to *Stenopilus*.

There are a number of Upper Cambrian genera which are characterized by a peculiarly modified opisthoparian facial suture in which the posterior branch runs outward beyond the lateral border furrow before turning backward to cut the posterior margin within the genal angle, so that the genal spine or the outer portion of the genal angle is always carried by the free cheek. When only the cranidium is known, the specimen may be interpreted as having a proparian facial suture; but when a complete cephalon is obtained, the opisthoparian nature of the suture is readily determined. I have decided to group these genera into one family, the Cedariidae Raymond, 1937, the first family described in which the peculiar nature of the suture was recognized. It is clear that the family as a whole is of polyphyletic origin, this facial suture type arising independently in several different stocks probably in response to a particular environment, but certain of the genera, such as *Cedaria* and *Cedarina* or *Genevievella* and *Llanoaspis* may be related.

Three subfamilies of the Cedariidae are recognized: the Cedariinae Lochman, nov., with *Cedaria* Walcott, 1925, and *Cedarina* Lochman, 1940; the Llanoaspinae Lochman, 1944, with *Llanoaspis* Lochman, 1938, *Genevievella* Lochman, 1936 (syn.: *Stenelymus* Raymond, 1937), and *Metisaspis* Rasetti, 1946; and the Raymondininae Clark, 1924, emended, with *Raymondina* Clark, 1924, *Amquia* Rasetti, 1946, *Brassicicephalus* Lochman, 1940, *Llanoaspidella* Tasch, 1951, and *Paracedaria* Duncan, 1949.

The Cedariinae are defined as: Trilobites with opisthoparian, elliptical exoskeleton, isopygous; facial suture—posterior branch running beyond lateral border furrow before turning posteriorly to cut posterior margin, tending to curve forward to approach the anterior branch with which it may meet and fuse, anterior branch straight or diverging widely, glabella conical, three pairs of glabellar furrows faint or obsolete, preglabellar area present, eyes medium sized, opposite or slightly anterior to center of glabella, fixed cheek horizontal—palpebral area about one-third glabellar width; free cheek with medium-length genal spine. Thorax of seven segments. Pygidium semicircular to transverse, axis tapered, nearly full length, narrower than pleural regions, furrows distinct, border may have small margin spines.

In 1938 Resser placed *Llanoaspis* in synonymy with *Genevievella*. However, the two are generically distinct and for complete clarification a diagnosis of each is now given.

Genevievella Lochman, 1936

Cranidium:

1. Palpebral lobe just under medium size, slightly posterior to center of glabella.
2. Glabella convex, conical, sides tapered to broadly rounded front, three pairs of faint glabellar furrows.
3. Fixed cheek—palpebral area one-half glabellar width, upsloping.
4. Fixed cheek—posterior area expanding at ends, about same length (tr.) as occipital ring.
5. No pre-glabellar area, an anterior border furrow and anterior border.

Pygidium:

1. Subcircular, axis convex, tapered nearly full length to rounded end.
2. Pleural platforms same width, pleural furrows curve back and fade out on border, no border furrow.
3. Posterior margin regularly curved.

Llanoaspis Lochman, 1938

Cranidium:

1. Palpebral lobes about medium size, on or back of posterior third of glabella.
2. Glabella moderately convex, subrectangular, front flatly rounded, three pairs of short glabellar furrows.
3. Fixed cheek—palpebral area one-half to two-thirds glabellar width, upsloping.
4. Fixed cheek—posterior area expanding

at ends, one and a half times length (tr.) of occipital ring.

5. No pre-glabellar area, an anterior border furrow, prominent anterior border.

Pygidium:

1. Broadly transverse, axis narrow, tapered nearly full length.

2. Pleural platforms wider than axis, interpleural grooves turn back across faint border furrow and fade out on border.

3. Posterior margin sinuous.

The two genera differ in the cranidium in the shape of the glabella, the position of the palpebral lobes, the shape of the anterior border and the width of the posterior area, and in the pygidium both in the shape and the character of the posterior margin. *Llanoaspis* is not yet known to occur in other than the *Crepicephalus* zone assemblages. *Genevievella* makes its appearance in and is most characteristic of faunas of the upper half of the *Cedaria* zone, but it does continue into the lower part of the *Crepicephalus* zone.

The Ptychaspidae Raymond, 1924, are recognized as a separate family, at best only remotely related to the Dikelocephalidae. The stock developed in the northeastern Asian-northern Cordilleran basins from ptychoparid ancestors in the early Upper Cambrian. Two early genera, *Anderssonella* in Asia and *Conaspis* in North America made their appearance in the early Franconian. Nelson (1951) has shown the development of *Eoptychaspis* and *Ptychaspis* from *Conaspis*. Possibly *Euptychaspis* also belongs in this line. *Anderssonella* and probably related, as yet unknown, genera appear to have given rise to two lines, one characterized by *Keithia* and *Keithiella*, the other by *Stigmaspis* and *Quadraticephalus*.

Shaw (1951) established two subfamilies, the Norwoodiinae and the Holcacephalinae, in the Norwoodiidae. I have been unable to recognize any valid or clear-cut basis for such a division in my study of the Norwoodiidae. *Norwoodia*, *Norwoodella* and *Holcacephalus* are closely related although the first two are placed in the Norwoodiinae and the last in the Holcacephalinae. *Holcacephalus* does not possess most of the characters ascribed to this subfamily as the subfamily description seems to have been based actually on the much later genus, *Hardyoides*.

I cannot agree with Shaw's (1952) emendation of the Menomoniidae to include genera with an opisthoparian facial suture and a median boss on the pre-glabellar area. In his definition of the family Shaw simply added the characteristics of the Nepeidae and so enlarged the group, but he did not describe or cite any known series of genera which would demonstrate the connecting link between the two families. The three Dresbachian genera, *Menomonia* Walcott, 1916, *Densonella* Shaw, 1952 (syn.: *Millardia* Walcott, 1916), *Dresbachia* Walcott, 1916, and the slightly earlier genus, *Bolaspidella* Resser, 1937 (syns.: *Apedopyganus* Raymond, 1937, *Hysteropleura* Raymond, 1937, *Howellaspis* Lochman and Denson, 1944), which appears in latest Middle Cambrian and continues into the base of the Dresbachian, all form a compact group, the Menomoniidae, characterized by a gonatoparian facial suture, multi-segmented (20–42) thorax, depressed pre-glabellar area, fixed cheeks upsloping to elevated so that small eyes may appear stalked, eyes located anterior to center of glabella. *Bolaspidella* is clearly the ancestral form, having the most generalized expression of each feature, and would, by the modification of the rim-like anterior border and the depressed preglabellar area pass readily into a generalized Middle Cambrian ptychoparid. I wish to call attention to the fact that although Walcott originally defined the Menomoniidae as proparian, the course of the posterior branch of the facial suture is truly gonatoparian, cutting the genal angle exactly through the middle. Poor preservation of many specimens and consequent uncertainty of the position have led to subsequent varied opinions.

Bolaspidella cannot be so modified as to lead back to *Bolaspis*, which appears only slightly earlier in the late Middle Cambrian than *Bolaspidella*, and in which the distinctive feature of the median boss of the preglabellar area is well developed. *Bolaspis*, *Acrocephalops*, *Eldoradia* and *Nepea* form a group of related genera occurring in the upper half of the Middle Cambrian. They are all characterized by a definitely opisthoparian facial suture, a cephalon with wide fixed cheeks small (never stalked) eyes and

a median boss on the pre-glabellar area, and a multi-segmented thorax. This group, the so-called Nepeidae, would by loss of the median boss and lessened convexity of the anterior border pass readily also into a generalized Middle Cambrian ptychoparid; but this ancestral ptychoparid genus must have lived in the early Middle Cambrian, for its descendants, the Nepeidae, lived during the later Middle Cambrian and thus were contemporaneous with the ancestral ptychoparid of the Menomoniidae.

Shaw (1952) suggests that the median boss is a feature of the adult cranidium only, but does not state what size limit he considers as adult. Apparently he would imply that the cranidia of the Menomoniidae lack the median boss because of their small size; yet an examination of the figured cranidia of the various genera of the two groups shows that the known cranidia of the genera of the Menomoniidae are within the same size range as those of the Nepeidae.

I am at present excluding the genera, *Knechtelia* and *Bridgeia* from the Menomoniidae. The course of the facial suture cannot be correctly determined until the free cheek is known for each, for the shape of the posterior limb cannot be relied upon.

The Komaspidae Kobayashi, 1935, and the Elviniidae Kobayashi, 1935, are recognized as separate and distinct but related families derived from a common ancestor, a generalized ptychoparid genus (see fig. 1), living in the Arctic-Asia basin during the middle of the Middle Cambrian. The Elviniidae were a more conservative, less vigorous and short-lived line, whereas the Komaspidae were more progressive, longer-lived, and gave rise to a number of widespread genera and the later Ordovician Telephidae (Stubblefield, 1950). Figure 1 shows the lines of descent and the assumed appearance of the common ancestor.

The basic stock of the Komaspidae comprises the genera *Komaspis* (late Middle Cambrian), *Irvingella* (upper Cambrian), and *Irvingelloides* (Lower Ordovician). Through this long time span these three genera show only very minor changes, and

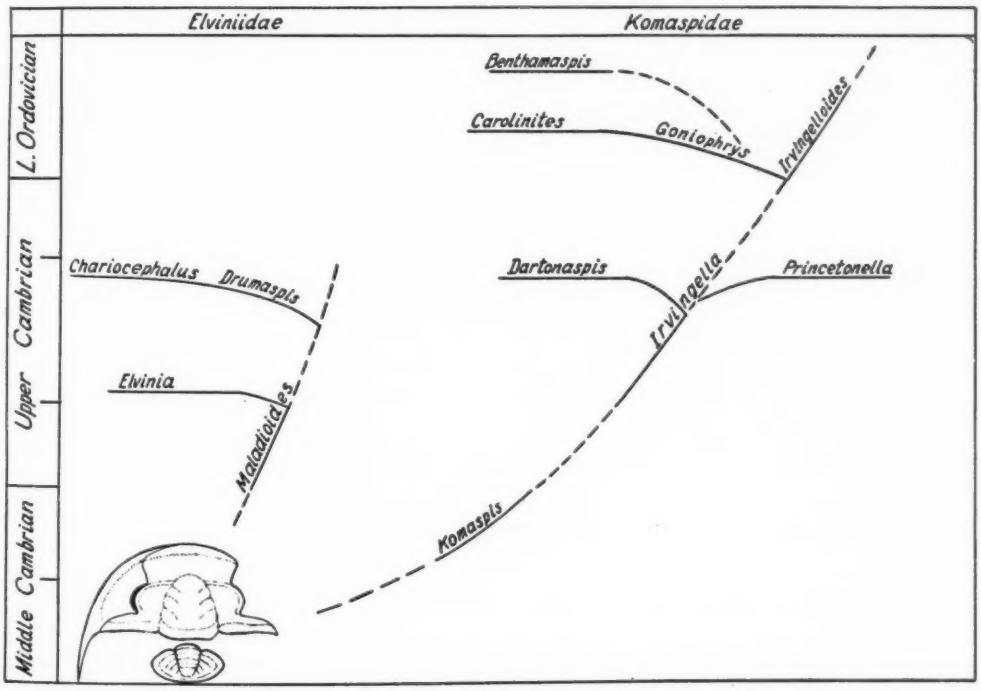

FIG. 1—Assumed appearance of common ancestral genus and lines of descent of Elviniidae and Komaspidae.

during the Upper Cambrian *Irvingella* achieved circumboreal distribution and gave rise to at least four specialized genera.

By the late Middle Cambrian the basic familial characteristics of the cephalon and presumably the rest of the exoskeleton had been acquired by *Komaspis*. These are: (1) the slightly over medium-size eyes tending to be slightly anterior to the center of the glabella; (2) the shortening (tr.) of the posterior limbs; (3) the posterior and even the second glabellar furrows commonly deep and complete; and (4) the narrowing of the pre-glabellar area and a rim-like border. The broadly conical glabella with narrowly rounded front (called ovately triangular by Kobayashi) is a feature believed inherited from the ancestor and retained to the end in this basic line. The major evolutionary trends of the family are expressed primarily in the cephalon and are: (1) broadening of the anterior lobe of the glabella; (2) obsolescence of the glabellar furrows; (3) loss of pre-glabellar area and anterior border furrow; (4) increase in size of eyes and palpebral lobes; (5) loss of eye platform of free cheek; and (6) extreme shortening (tr.) of posterior limbs. In the basic line these trends were developed only incompletely and slowly. Thus the earliest known species of *Irvingella* (basal Franconian) differ from *Komaspis* only in the increased size of the eyes and the fading of the second glabellar furrows. A more advanced type of *Irvingella* developed rather rapidly at this time; it is exemplified by *I. major* Ulrich and Resser, in which progress was made in trends 1 and 6 and trend 3 was achieved (Gaines, 1951, pp. 614–616). Both primitive and advanced types of *Irvingella* continued to live together in the circumboreal basin during the Upper Cambrian (Westergård, 1947, 1949) producing new genera which moved southward into the North American province. In the upper Franconian *Dartonaspis* and *Princetonella* were derived from the variant species of *Irvingella*. *Dartonaspis* is so similar in appearance to its ancestor, simply because in it the evolutionary trends have been continued, that it is the genus which in the early studies of the Upper Cambrian of Wisconsin was referred to frequently as a recurrent *Irvingella* of the *Ptychaspis-Prosaukia* zone. In *Dartonaspis* (1) the broad quadrate glabella with anterior lobe sometimes slightly expanded; (2) the fading of the glabellar furrows, even the posterior pair may be incomplete; (3) the absence of pre-glabellar area; (4) the very long eyes; (5) reduced eye platform; and (6) very small posterior limbs mark the first culmination of the evolutionary trends in this family. *Princetonella* arose independently from *Irvingella;* it retained a primitive shaped glabella while assuming most advanced expressions of trends 2 to 6.

At the end of the Upper Cambrian the boreal species of *Irvingella* produced several more genera—*Goniophrys* from a primitive type and *Irvingelloides* from an intermediate type. The latter genus (Lower Ordovician of Korea) though poorly known, is most interesting in indicating the extreme conservatism of the basic line of the Komaspidae. *Irvingelloides* is distinguishable from *Komaspis* only in a few minor features: the apparent absence of a pre-glabellar area and anterior border furrow and the larger size of the palpebral lobes, as in *Irvingella*. The posterior and second glabellar furrows are still complete as in *Komaspis* and a few species of *Irvingella*. The free cheek associated with the fragmentary cranidium by Kobayashi could not possibly belong to it as the specimen is interpreted by Kobayashi, who describes an inflated crescentic area as an eye platform. This fragmentary free cheek (I believe the anterior portion is broken off) appears very similar in structure to that of *Carolinites*, with the crescentic area actually being the large eye, the eye platform lost, and the large genal spine in lateral position as in *Carolinites*. However, until more material of *Irvingelloides* and its associated fauna is obtained, it is impossible to say whether this free cheek belongs to *Irvingellcides* and indicates that only in trend 5 was the genus progressive, or whether it really belongs to *Carolinites*, a genus whose stratigraphic position in Utah and known geographic distribution indicate that it could very well have been a member of the fauna of the *Clarkella* zone of Korea.

Goniophrys appears to have developed from an Upper Cambrian form such as *Irvingella suecica marginata* Westergård, from which it differs only in the obsolescence of the glabellar furrows and the some-

what sharper flexure of the palpebral lobes. *Goniophrys* gave rise to *Carolinites* by the loss of the pre-glabellar area and anterior border furrow, the expansion of the anterior lobe of the glabella and the enlarging of the eyes and palpebral lobes, thus repeating the same trends which had been followed in the Upper Cambrian genera. The late Canadian genus *Benthamaspis* apparently was derived also from *Goniophrys* by a similar development. *Goniophrys* must have been circumboreal in distribution and Hintze's material (1952) suggests that *Carolinites* developed from *Goniophrys* in the Cordilleran portion of the Arctic basin. *Carolinites* migrated thence westward into the Asiatic seaways and as far south as Tasmania. It could have moved either eastward or westward to reach the British Islands, and thus have had wide distribution in the boreal regions. Considering the vigor of this Lower Ordovician stock it seems highly probable that the Komaspidae did give rise to the later Ordovician Telephidae, and it is now obvious that the two families did originate in the Arctic basin as believed by Ulrich.

Several genera of the related Elviniidae have commonly been either placed in the Komaspidae or confused with genera of the Komaspidae, a situation caused by the fact that the Elviniidae, in their slower and shorter evolutionary development, show a parallelism in certain of the major trends. This parallelism appears readily attributable to their descent from a common ancestral genus. However, a consideration of basic evolutionary principles and a careful tabulation of the time of appearance of the genera readily indicates the correct lines of descent.

The earliest genus of the Elviniidae is *Maladioides* (and the poorly known, probably synonymous *Taishania*) from the early Upper Cambrian of northeast Asia. *Maladioides*, although later in time than *Komaspis*, is only very slightly changed from the ancestral genus, differing from it only in the position of the eyes slightly anterior to the center of the glabella, and the truncate front of the normal conical glabella found in some species.

From *Maladioides* there developed two genera which migrated into the North American province through the northern Cordilleran seaway and became widespread and important members of the Franconian faunas. The earliest is *Elvinia*, which retains the truncato-conical glabella, the normal pre-glabellar area and anterior border, and the medium length posterior limb of *Maladioides*, and differs from that genus only in the complete posterior glabellar furrow, and the slightly smaller size and more forward position of the eyes. Wilson (1951) has figured an interesting small (2 mm.) cranidium of *Elvinia roemeri* in which the palpebral lobes are proportionately larger and nearer the center of the glabella than in the adult, so that the small holaspid cranidium approaches even closer to the ancestral *Maladioides* in appearance. Although both abundant and widespread, *Elvinia* died out without descendants at the end of *Elvinia* zone time.

Drumaspis appears later in the *Ptychaspis-Prosaukia* zone, and is represented abundantly in the Cordilleran region and the Mississippi Valley. Most of Resser's (1942) species belong to *Drumaspis*, but *D. utahensis* is a *Dartonaspis*, and *D. goodsirensis* might prove to be also if good material were available. *Drumaspis* remains conservative in most features also: the eyes are just over medium size, are very slightly anterior to the center of the glabella, the posterior limbs are medium length (tr.), and the posterior glabellar furrow may be complete or incomplete; but in two features of the glabella *Drumaspis* parallels trends which had been developed in the Komaspidae by the much earlier *Irvingella*. These are the gradual reduction in width and final loss of the preglabellar area and anterior border furrow, and the gradual broadening of the front of the glabella to give the glabella a quadrate shape. The described species of *Drumaspis* illustrate a nearly unbroken series with *D. texana* and *D. walcotti* examples of less modified species, *D. idahoensis* an intermediate species, and *D. alberta* an advanced species. This advanced type is the obvious ancestor of *Chariocephalus whitfieldi*, since all that is required to produce *Chariocephalus* is a forward movement of the eyes (a trend which can already be detected in the known species of *Drumaspis*), and a weaker development of the glabellar furrows. The already known variability of *Drumaspis* suggests

that when northwest Cordilleran faunas are better known, species bridging the short gap between *Drumaspis* and *Chariocephalus* will be found. It should be noted that in all genera of the Elviniidae the eye platform of the free cheek remains of medium width and only the anterior end is narrowed in *Drumaspis* and *Chariocephalus* in response to the narrowing and loss of the pre-glabellar area.

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JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, PP. 897–898, NOVEMPER, 1953

REVIEWS

THE JACKSONIAN STAGE IN SOUTHEASTERN ARKANSAS. Wilbert, Louis J., Jr., Arkansas Resources and Development Commission, Division of Geology, Bull. 19, 1953, 125 pp., 25 figs., 2 plates, tables.

Release of "The Jacksonian Stage in Southeastern Arkansas" marks the appearance of another fine volume on the geology of that state. It will be as classic for the Jacksonian as previous ones on the Paleozoic (Croneis), Upper Cretaceous (Dane), Jurassic and Lower Cretaceous (Imlay), and oil and gas geology (Spooner). Summarily, it is the first thoroughly documented study of the most accessible and representative Jacksonian sediments in the Mississippi Embayment.

The outcrops in southeastern Arkansas are situated on the western flank of the Desha Basin, a closed structural downwarp located north of the Monroe-Sharkey Uplift of Louisiana, Arkansas, and Mississippi.

Wilbert points out that the Jacksonian outcrops are inliers, completely isolated from the main body of Jacksonian sediments, which crop out farther south in a belt roughly parallel to the coastline. According to him, the sediments exposed in these outcrops are both marine and nonmarine and overlie typically nonmarine Claibornian sediments, sometimes with disconformity and sometimes without evidence of pronounced breaks in sedimentation.

Marine portions of the sequence are classified by Wilbert as the White Bluff formation while nonmarine beds are grouped as the Redfield formation. He considers the White Bluff beds to have formed under three distinct sets of environmental conditions as indicated by three separate marine facies: (1) Pastoria sand member, which includes the coarser clastic elements of the formation, and is characterized paleontologically by a distinctive fauna, chiefly molluscan; (2) Caney Point marl member, which includes the more calcareous and glauconitic elements of the formation and is characterized paleontologically by a varied fauna including mollusks, foraminifers, ostracodes, corals, bryozoans, and echinoids; and (3) Rison clay member, which includes argillaceous and subordinate coarser clastic elements, characterized generally by a sparse fauna consisting of arenaceous foraminifers and small mollusks (molds), but locally containing molluscans (molds) concentrated in thin discontinuous beds. The Redfield formation varies lithologically, consisting principally of sand and silt, generally well bedded, with fossil leaves and other plant remains.

The Caney Point and Pastoria members are interpreted by Wilbert as products of transgressive and inundative phases of a depositional cycle which occurred in the Desha Basin during the latest part of early Jacksonian time. He considers the lithological and paleontological differences between the two units as due to facies variations caused principally by proximity of the delta of a river of medium size and points out that the deltaic deposits are located in the northern part of the basin, near the area where the Pastoria sand member is developed. He further interprets the Redfield formation and the Rison member of the White Bluff formation as products of the regressive phase of the sedimentary cycle, stating that the nonmarine Redfield deposits accumulated near the source of the sediment, and the Rison clay beds farther from the deltaic influence in a partially isolated body of brackish water.

Other sections are devoted to (1) nature, pattern, and physiographic expression of the outcrops; (2) contact relationships; (3) detailed descriptions and definitions of the new units; (4) basal contact in Mississippi, Louisiana, and Arkansas; (5) conditions of deposition; (6) fossils, including figures of species and charts showing stratigraphic distribution of all recorded forms; (7) effects of geographic isolation of faunas; (8) regional implications of the study; (9) bibliography; and (10) descriptions of localities.

This posthumous report by Louis J. Wilbert, Jr., is well illustrated, carefully documented, and lucidly, as well as interestingly,

written. It represents the culmination of his doctoral studies and research and is a scientific article worthy of addition to all our libraries.

GROVER E. MURRAY
Louisiana State University

PRE-CORNELL AND EARLY CORNELL I (AGASSIZ AND CORNELL). Albert Hazen Wright, 1953, (Studies in History No. 15). 51 pp., 8 figs., 7×10 in., paper. A. H. Wright, 113 E. Upland Rd., Ithaca, N. Y. Price $1.35.

PRE-CORNELL AND EARLY CORNELL II (LETTERS TO C. F. HARTT). Albert Hazen Wright, 1953 (Studies in History No. 16). 60 pp., 8 figs., 7×10 in., paper. A. H. Wright, 113 E. Upland Rd., Ithaca, N. Y. Price $1.35.

These two volumes mark the appearance of a series by A. H. Wright, Professor Emeritus of Zoology in Cornell University, effectively constituting source-books of early Cornell backgrounds. For those interested in the historical approach to geology and paleontology, these cross-sections of the middle to late Nineteenth Century, as recorded in letters by Agassiz and his contemporaries, are both interesting and informative.

GROVER E. MURRAY
Louisiana State University

BIBLIOGRAPHY OF UTAH GEOLOGY. Walter R. Buss, 1951. 219 pp., 6×9 in., paper. Utah Geological and Mineralogical Survey, Salt Lake City, Utah. Price $4.00.

This useful bibliography, datelined 1951, reached the writer's desk in 1953. Although it does not pertain solely to paleontology, it is noteworthy for dealing with an area of interest to such famous precoursers of modern geology as John Wesley Powell, George M. Wheeler, Grove Karl Gilbert, Clarence King, and Clarence E. Dutton. Publications to December 31, 1950, are included.

The bibliography follows the style of the Bibliography of North American Geology published by the Federal Survey. Part I contains alphabetical listings by authors.

Approximately 250 articles concerning paleontology are included in the listings.

GROVER E. MURRAY
Louisiana State University

A NEW MASTODONT FROM THE MIOCENE OF OREGON, WITH REMARKS ON *GOMPHOTHERIUM*. Theodore Downs. University of California Publications in Geological Sciences, vol. 29, no. 1, pp. 1–20, 2 figures in text, February 1952, $0.35.

Since the massive volumes on the probosciderms by H. F. Osborn appeared, very little comprehensive work has been undertaken on this group of mammals. The lack of description of a new mastodont from Oregon forced Dr. Downs to review the earlier primitive mastodonts of North America and several of the related forms found in Eurasia. For this reason Dr. Down's paper is a most useful contribution; he has saved many people much leg work. Unfortunately the specimen was not associated with other mammalian fossils, so it is difficult to assign it an age other than middle or late Miocene. The suggestion that the Oregon *Gomphotherium* is older than other specimens because of its proximity to the Bering Strait land bridge is somewhat dangerous at the present state of our knowledge concerning dispersal rates of mammals in geologic time.

JOHN ANDREW WILSON
University of Texas

JOURNAL OF PALEONTOLOGY, VOL. 27, NO. 6, P. 899, NOVEMBER, 1953

NEWS AND EVENTS

The SOUTHWESTERN ASSOCIATION OF NATURALISTS was formed at an organizational meeting attended by fifty-two persons at the University of Oklahoma Biological Station at Lake Texoma on May 23, 1953. As stated in the constitution, "The object of the Association shall be to promote the field study of plants and animals, living and fossil, in the Southwestern United States and Mexico, and to aid the scientific activities of its members." SWAN hopes to stimulate the study of the region by bringing together persons of like interests through publication of annotated membership lists, annual meetings, and perhaps later through the publication of a journal.

The officers elected for the first year were: W. Frank Blair (Vertebrate Zoology) University of Texas, *President;* George J. Goodman (Plant Taxonomy) University of Oklahoma, *Vice-President;* Herndon G. Dowling (Herpetology) University of Arkansas, *Secretary-Treasurer.* The geographic scope of the Association at present includes Mexico and the states of Arizona, Arkansas, Kansas, Louisiana, New Mexico, Oklahoma, and Texas. Persons interested in the natural history of this region are invited to join the Association. Membership blanks may be obtained from any of the officers.

The Eighth Pacific Science Congress of the Pacific Science Association and the Fourth Far-Eastern Prehistory Congress are scheduled for joint meetings, November 16–28, 1953, on the campus of the Universtiy of the Phillipines, Quezon City, Phillippines, under the auspices of the Republic of the Phillipines and the national Research Council of the Phillipines.

Extensive programs of interest to geologists include symposia on:

(1) Progress of geologic mapping in the Pacific Basin;
(2) Plutonics of the Pacific area;
(3) Petrography and geology of the basement complex;
(4) Geologic history, paleontology, and stratigraphy of the Pacific Basin;
(5) Petroleum provinces of the western Pacific;
(6) Ore deposits of the Pacific Basin;
(7) Seismology of the Pacific;
(8) Volcanology of the Pacific;
(9) Significant geologic structures of the Pacific;
(10) Marine provinces in the Indo-Pacific region;
(11) General circulation in the Pacific; and,
(12) Ecology of coral atolls.

Related topics of some interest to specialists are scheduled for discussion in the sessions on Meteorology, Oceanography, Zoology, Botany, Soil Resources, Forestry, and Anthropology.

Headquarters offices of the Society of Exploration Geophysicists have been moved to the Elm Oil building at 624 South Cheyenne, Tulsa, Oklahoma.

Officers of the SEG are: Roy L. Lay, The Texas Company, Houston, Texas, *President;* Dr. Karl Dyk, Stanolind Oil & Gas Company, Tulsa, Oklahoma, *Vice-President,* Nart W. Sorge, United Geophysical Company, Pasadena, California, *Secretary-Treasurer;* Dr. Milton B. Dobrin, Magnolia Petroleum Company, Dallas, Texas, *Editor;* and Curtis H. Johrson, Geophysical Service Inc., Dallas, Texas, *Past President.*

JOURNAL OF PALEONTOLOGY, VOL. 27, MO. 6, PP. 900–901, NOVEMBER, 1953

SOCIETY RECORDS AND ACTIVITIES

ANNUAL MEETING, ST. LOUIS, MISSOURI, APRIL 12–15, 1954

The annual meeting of the Society of Economic Paleontologists and Mineralogists will be held in St. Louis, April 12–15, 1954, in conjunction with the Society of Exploration Geophysicists and the American Association of Petroleum Geologists. Technical programs will be held in the Opera House and commercial and educational exhibits will be displayed in the Convention Hall of St. Louis' Kiel Auditorium, according to Graham B. Moody, Standard Oil Co. of California, San Francisco, who is General Convention Chairman. The Jefferson Hotel has been designated the headquarters hotel.

Norman S. Hinchey, Washington University, St. Louis, is General Chairman for the S.E.P.M. H. A. Ireland, University of Kansas, Lawrence, Kansas, is chairman of the technical program.

The technical program will include two symposia. One, "Regional Aspects of Carbonate Deposition," is being organized by R. J. LeBlanc, Shell Oil Co., Houston, Texas. The other will be organized by the Research Committee, whose chairman is E. C. Dapples, Northwestern University, Evanston, Illinois.

GULF COAST SECTION OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

Steering Committee

JACK O. COLLE
STUART A. LEVINSON
FRED L. SMITH, JR.
MORTON B. STEPHENSON
FRANK V. STEVENSON
CHARLES W. STUCKEY

Advisory Committee

OLIN G. BELL
JULES BRAUNSTEIN
MARCUS A. HANNA
HENRY V. HOWE
URBAN B. HUGHES
LOUISE JORDAN
JAMES L. MARTIN
WINNIE MCGLAMERY

Recently a steering committee was formed to establish a Gulf Coast Section of the Society of Economic Paleontologists and Mineralogists. A petition requesting authorization of the Section has now been approved by the council of the S.E.P.M., so that the Section may engage in active organization.

The primary objective of the Section is to promote the science of Stratigraphy *in the Gulf Coastal states* through research in paleontology and sedimentary petrology, especially as it relates to Petroleum Geology. A secondary objective is to create an elected group responsible for the co-ordination of paleontologic and petrologic activities in the Gulf Coast area, which will promote the recognition of the sciences of Paleontology and Petrology.

All members or associate members of the S.E.P.M., and workers actively engaged in paleontologic, stratigraphic, or petrologic studies that have application to the geology of petroleum and who work or reside in the Gulf Coast province of the states of *Alabama*, *Mississippi*, *Louisiana*, *Georgia*, *Texas*, and *Florida* are qualified for membership in the Section. An annual business meeting will be held in the Gulf Coast area, possibly in conjunction with the annual meetings of the Gulf Coast Association of Geological Societies. It is planned that the Section will cooperate with the Association and local geological societies by presenting paleontologic, stratigraphic, and petrologic papers, assisting in the preparation of field trips and cooperating in outside activities, such as Boy Scout counseling.

The present steering committee is a temporary group to be active only until the first election of officers. The primary duty of the first officers of the Section will be to frame a constitution. The first officers will be elected in the following manner. Each of the

local Gulf Coast Geological Societies will select one man from the list of Section members in their respective areas to serve as a nominating committeeman. These committeemen will then be divided into two groups, each group having as wide as possible geographic distribution. The chairman of the steering committee will appoint one member of each nominating committee to serve as chairman. Each nominating committee will agree upon a slate of nominees and from the two slates submitted the total membership of the Section will elect the first officers.

Application blanks may be obtained from the Treasurer of the steering committee, Frank V. Stevenson, 1300 City National Bank Building, Houston, Texas.

S.E.P.M. COMMITTEES AND REPRESENTATIVES

The entire S.E.P.M. Council acts as an advisory body to the A.A.P.G. Committee on National Responsibility.

A.G.I. GOVERNMENT RELATIONS COMMITTEE: T. H. Philpott

A.G.I. REPRESENTATIVES:* *Senior:* T. H. Philpott
Junior: C. C. Church

NATIONAL RESEARCH COUNCIL: W. C. Krumbein

GLOSSARY COMMITTEE: W. D. Pye

NOMINATING COMMITTEES:

1. *Chairman:* M. A. Hanna
   Members: T. H. Philpott, G. Rittenhouse
2. *Chairman:* M. C. Israelsky
   Members: A. O. Woodford, R. D. Russell

RESEARCH COMMITTEE:

Chairman: E. C. Dapples
Members: G. E. Murray, F. W. Rolshausen, L. E. Workman, H. A. Lowenstamm, H. E. Summerford, F. J. Pettijohn, B. Kummel, E. D. McKee

ADVISORY COMMITTEE ON RADIOACTIVE MINERAL EXPLORATION:

J. G. Bartram, R. F. Beers, C. C. Church, H. C. Cortes, C. H. Green, S. Hammer, G. Herzog, M. T. Higgs, J. H. Johnson, A. I. Levorsen, C. L. Moody, R. R. Rieke, W. B. Tapper, G. H. Westby

GENERAL CHAIRMAN FOR 1954 ST. LOUIS MEETINGS—N. S. Hinchey

CHAIRMAN TECHNICAL PROGRAM, 1954 ST. LOUIS MEETINGS—H. A. Ireland

HEAD, SYMPOSIUM ON CARBONATE ROCKS FOR 1954 ST. LOUIS MEETING—R. J. LeBlanc

BY-LAWS COMMITTEE:

Chairman: M. B. Stephenson
Members: J. F. Rominger, T. H. Philpott

* After November meeting. Present senior representative: W. C. Krumbein. Present junior representative: T. H. Philpott.

The Pacific Section of the S.E.P.M. held its annual meeting in conjunction with the Pacific Section of the A.A.P.G. November 5 and 6, 1953, in the Biltmore Hotel in Los Angeles. New officers for 1954 are: *President:* John W. Ruth, Standard Oil Company, Los Angeles, California, and *Secretary-Treasurer:* Wayne Elliott, Richfield Oil Corporation, Long Beach, California.

Abstracts of papers presented are:

CLASSIFICATION OF SPORES AND POLLEN FOR PALEONTOLOGIC CORRELATION

W. L. Norem
California Research Corporation,
La Habra, California

One of the more important recent developments in micropaleontology is the use of plant spores and pollen for correlation purposes. These minute bodies are found in many sediments previously considered barren of diagnostic fossils. The classification of spores and pollen presents a complex problem because of the large number of types that represent almost every phylum of the plant kingdom and cover the geological time span from the Paleozoic to the present.

Classification under the International Rules of Botanical Nomenclature is confusing because materials of known affinities are classified according to phylogenetic relationships and those of unknown parentage according to morphological characteristics. No clear cut distinction is made in the nomenclature between fossils classified in the natural and the artificial systems. A natural system is not necessarily the most satisfactory for the stratigraphic paleontologist because of the vast knowledge of systematic botany required for its application.

If fossil spores and pollen are to be brought quickly into usefulness for paleontologic correlation, a system of classification that is easy to use must be developed. Such a system must have a minimum possibility for confusion in its application. It must be comprehensive enough to cover all spore types from the Paleozoic to the present. It should contain the elements of a key for quick and easy reference. Like the International Rules of Botanical Nomenclature, its use should be universal so as to permit the free interchange of information on spores and pollen.

The classification based on morphological characteristics and proposed by G. Erdtman contains the elements of such a system. It must, however, be expanded in scope before it will be complete.

This artificial system is not intended to replace the natural system under the International Rules in paleobotany but it is intended as a practical substitute for use in stratigraphic paleontology. The fossil spores or pollen can be reclassified under the natural system when and if the affinities are ascertained.

SIZE DISTRIBUTION OF GRAVELS

K. O. Emery
University of Southern California

More than 60 samples of gravel from beaches of Mexico and southern California were mechanically analysed in the field using a new method. Median diameters range between 20 and 800 mm. Trask sorting coefficients are characteristically lower than 1.5 and have a median of 1.25. Comparison with published analyses shows that the marine beach gravels are far better sorted than gravels from streams and alluvial fans. The difference is sufficiently great that sorting may be a useful supplementary means of determining the environment in which ancient conglomerates are deposited.

EOCENE FORAMINIFERA FROM THE WOODSIDE DISTRICT, SAN MATEO COUNTY, CALIFORNIA

Joseph J. Graham
Stanford University

An Eocene foraminiferal assemblage from the Woodside district near Redwood City, San Mateo County, California, is described and its similarity to Cushman and Siegfus' Canoas siltstone faunule from the type area of the Kreyenhagen shale of California noted.

RECOGNITION OF PLAYA SEDIMENTS IN THE GEOLOGIC COLUMN

Richard Stone
University of Southern California

Playa sediments are sometimes reported in oil well cuttings, particularly in sediments whose age is Miocene or younger. A careful investigation of the sedimentary properties of playa sediments of the present has revealed certain characteristics which it is believed will enable the geologist to definitely recognize older sediments which were deposited in the playa environment. These diagnostic properties include the average grain size, sorting coefficient, color, organic carbon content, alkali and salt content, hydrogen ion concentration, and the oxidation-reduction potential. In playa sediments most of these properties have rather definite ranges. This makes it possible to recognize playa sediments with a greater degree of certainty.

GENESIS OF PELAGIC SEDIMENTS

Gustaf Arrhenius
Assistant Research Oceanographer, Scripps Institution of Oceanography, Visiting Research Fellow, California Institute of Technology

The pelagic sediments form polydisperse systems where the liquid phase is the interstitial water, and the solid phase is built up by several genetically different components. In E. D. Goldberg's genetical system these are grouped according to the geological sphere in which the solid phase was separated. The solids are thus classi-

fied as lithogenous, hydrogenous, biogenous, atmogenous, cosmogenous and authigenous. Modern analytical methods make it possible to determine quantitatively the concentrations, and in ideal cases the rates of accumulation of these components.

SOME GUIDE FORAMINIFERA OF THE UPPER CRETACEOUS AND LOWER TERTIARY IN AUSTRALIA AND CALIFORNIA

STEWART EDGELL
Stanford University

A number of stratigraphically restricted species of Foraminifera are found in the late Cretaceous and early Tertiary of Australia and California. These cosmopolitan species are also found in many other parts of the world, often under different names. They have been noted in samples collected here for the Richfield Oil Corporation and for the Bureau of Mineral Resources in northwest Australia. Their identification permits direct or indirect correlation with standard European stages and thus contributes to a universal stratigraphy, as well as to the knowledge of paleogeography. In addition, the widespread occurrence of index Foraminifera for the Maastrichtian and Danian-Paleocene often permits an exact distinction between uppermost Cretaceous and lowermost Tertiary.

SOME SPECTACULAR EFFECTS OF WIND EROSION NEAR PALM SPRINGS, CALIFORNIA

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A short distance northwest of Palm Springs, California, a climbing dune has been formed in a gap in a spur of the San Jacinto Mountains that extends easterly into Coachella Valley. Wind funnelling through the pass between the San Jacinto and the San Bernardino Mountains picks up sand from the dry wash at the base of the spur and carries it up through the gap. The sand is coarse and the wind is almost constant, as a result of which spectacular wind effects have been achieved.

Juniper trees that have managed to grow at all have been bent over until the trunks have broken, and they are now growing in a prone position, with smaller plants crowding closely in their lee. Small plants also cluster in the lee of the larger projecting rocks, growing laterally rather than vertically. These rocks which are principally granitic, with some gneiss, schist, and quartzite, are pitted, grooved, and fluted in a most fantastic way. More fantastic still, however, is the fact that the grooving and fluting are continued without variation in the bushes sheltering behind the rocks.

CALIFORNIA LOWER TERTIARY FORAMINIFERAL SEQUENCE

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A preliminary statement of the formal names proposed for the major divisions and subdivisions of a chronologic-biostratigraphic classification of the California lower Tertiary, and a summary of the criteria upon which each of these is based is presented in this paper.

Evaluation of the faunal changes found in a complete stratigraphic sequence of foraminiferal faunas in the California Province has shown that this sequence of faunas resolves itself into six distinct major units of stage magnitude which are differentiable throughout the California Province, and several units of zonal magnitude which subdivide the stagial units based upon the joint occurrences of species of Foraminifera.

The major subdivisions of the Paleocene are the Ynezian and Bulitan stages constituting the oldest and next oldest stages of the Tertiary. The Eocene subdivisions are the Juniperan stage, lower Eocene; the middle Eocene Ulatisian stage; and the two upper Eocene stages, the oldest, the Narizian, and the youngest, the Fresnian stage.

The zonal subdivisions of these lower Tertiary stages of the California Province are the *Silicosigmoilina californica* and *Bulimina excavata* zones of the Ynezian stage; the *Bulimina bradburyi* and *Valvulineria wilcoxensis* zones of the Bulitan stage; the *Plectofrondicularia kerni* and *Alabamina wilcoxensis* zones of the Juniperan stage; the Ulatisian stage with three distinct zones, only one of which, the uppermost zone, the *Amphimorphina californica* zone is named; the *Uvigerina churchi* and *Uvigerina garzaensis* zones of the Narizian stage; at least two zones exist within the Fresnian stage, but these are not named at the present time.

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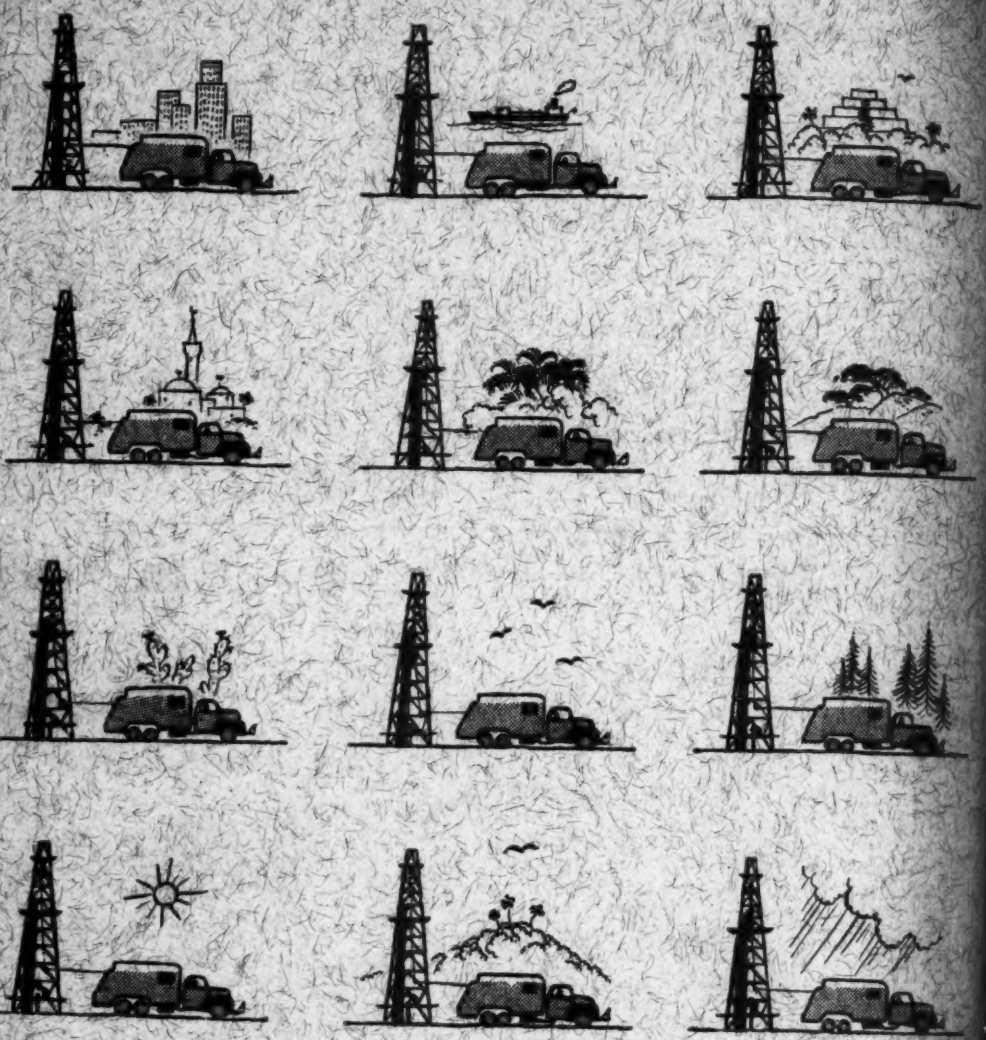

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